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Costs of Sulfur Dioxide, Particulate Matter, and Nitrogen Oxide Controls on Fossil Fuel Fired Industrial Boilers

Radian Corp.
Durham, NC

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This report is a resource document for the development of Federal standards of performance for control of sulfur dioxide, particulate matter and nitrogen oxides emissions from new industrial boilers. It gives capital and annualized costs for a variety of control technologies that can be applied to gas, oil, and coal fired industrial boilers. In addition to control costs for 30, 75, 150, and 400 million Btu per hour size model boilers, cost algorithms and a computer program are given in detail to allow for automated cost data development.

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Prepared by:

Michael L. Bowen
Mark S. Jennings
Radian Corporation
3024 Pickett Road
Durham, North Carolina 27705

EPA Project Officer: Larry G. Jones
Emission Standards and Engineering Division
Contract No.: 68-02-3058

U.S. ENVIRONMENTAL PROTECTION AGENCY
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1.0 INTRODUCTION

This report presents a cost analysis of particulate matter (PM), sulfur dioxide (SO_2), and nitrogen oxide (NO_x) controls on coal-, oil-, and gas-fired industrial boilers. For each boiler and control device the capital costs, operating and maintenance costs, and annualized costs are estimated. SO_2 and PM control costs are analyzed in Chapters 2-4 while NO_x control costs are analyzed in Chapter 5.

Chapter 2 discusses the methodologies and cost bases for estimating the boiler, PM control and SO_2 control costs. Chapters 3 and 4 then present the costs for coal- and residual oil-fired boilers, respectively. In Chapter 5, the costs of various NO_x controls (combustion modifications) are discussed. This chapter also outlines the cost methodologies used in addition to presenting the costs. The last chapter, Chapter 6, discusses the costs of firing low sulfur coal and low sulfur oil.

Four appendices are also included for reference. Appendix A is a listing of the cost algorithms used to estimate the boiler, PM control, SO_2 control, and NO_x control costs. Appendix B presents the FORTRAN computer program that utilizes these algorithms to develop the boiler and control device costs. Appendix C provides a detailed cost breakdown for all the cost cases studied. Finally, Appendix D presents two methods available to convert the costs calculated using the cost algorithms presented in this report (mid-1978 dollars) to a cost basis of a later year.

2.0 METHODOLOGY FOR CALCULATING SO_2 AND PM MODEL BOILER COSTS

This chapter presents the methodologies and cost bases used for calculating the costs of various SO_2 and PM controls that are applied to different types and sizes of industrial boilers. The emphasis of this analysis is to quantify the individual boiler cost impacts associated with the application of these emission controls. Both uncontrolled and controlled boiler costs are examined. By comparing the two, the incremental cost impact associated with the controls is assessed.

Section 2.1 describes the methodology used in this report to analyze the PM and SO_2 cost impacts on industrial boilers. Section 2.2 discusses the basic approach used in calculating the boiler and control device costs. The specific equipment specifications used to calculate the boiler and control device costs are presented in Section 2.3. Lastly, Section 2.4 presents annual costs due to reporting, compliance, and control device malfunction. These costs are treated separately from the boiler and control device costs presented in Chapters 3 and 4. All costs presented in this report are in mid-1978 dollars.

2.1 METHODOLOGY FOR ANALYZING THE PM AND SO COST IMPACTS ON INDUSTRIAL BOILERS

In this report, the cost impacts on various types and sizes of industrial boilers from applying various PM and SO_2 controls are assessed through an analysis of "model boilers." Model boilers form the basis of the PM and SO_2 control costs analysis. They are developed by applying different combinations of PM and SO_2 controls to a group of standard boilers that represent the population of new industrial boilers expected to be built. Standard boilers are defined as boilers without emission controls. In general, the model boilers are selected to cover a range of boiler sizes, fossil fuel types, and control methods. A brief description of the bases used for selection of the standard boilers, the PM controls, and the SO_2 controls follows.

A summary of the standard boilers selected for evaluation in this report is presented in Table 2-1. Factors considered in the selection were fossil fuel types, boiler distribution by capacity, heat transfer configurations and fuel firing methods. The principal industrial boiler fossil fuels are coal, residual oil, distillate oil, and natural gas. Because distillate oil- and natural gas-fired boilers have low uncontrolled PM and SO_2 emissions they were not considered in this analysis. Since coal properties such as sulfur and ash content can vary considerably, separate standard boilers were selected for both low sulfur coal (LSC) and high sulfur coal (HSC) applications.

The industrial boiler population is segmented into four size categories ranging in capacity from 30 to 400 x 10^6 Btu/hr. All four size categories are represented in the coal-fired boiler analysis (30, 75, 150, and 400 x 10^6 Btu/hr). All of the coal-fired boilers in this analysis are field-erected units except for the 30 x 10^6 Btu/hr unit which is a package boiler. In addition, they all have the same heat transfer configuration in that they are watertube units. The residual oil-fired population is smaller and is represented by two package boilers, 30 and 150 x 10^6 Btu/hr. The 30 x 10^6 Btu/hr boiler is a firetube boiler while the 150 x 10^6 Btu/hr boiler is a watertube unit. Construction of oil-fired boilers larger than 150 x 10^6 Btu/hr capacity is expected to be very limited.

Both residual oil-fired standard boilers utilize similar multi-fuel capable oil/gas burner designs. However, the coal-fired boilers vary in firing mechanism. Underfeed stokers typically occupy the lower end of the capacity range, and pulverized coal the upper end, with other stoker types occupying the intermediate range between the two. For the standard boilers, an underfeed stoker has been selected for the 30 and 75 x 10^6 Btu/hr boilers, a spreader stoker has been selected for the 150 x 10^6 Btu/hr boiler, and a pulverized coal unit has been selected for the 400 x 10^6 Btu/hr boiler. The specifications for these boilers and the fuels will be presented in Section 2.3.

The controls selected for the PM and SO_2 cost analysis include single mechanical collectors, side stream separators, venturi scrubbers,

TABLE 2-1. STANDARD BOILERS SELECTED FOR EVALUATION OF SO_2 AND PM CONTROLS

Boiler Code	Fuel	Heat Input Thermal 10^6 Btu/hr	Boiler Configuration
RES-30	Residual Oil	30	Package, Firetube
RES-150		150	Package, Watertube
HSC-30	High-Sulfur Coal	30	Package, Watertube, Underfeed Stoker
HSC-75		75	Field-Erected, Watertube, Underfeed Stoker
HSC-150		150	Field-Erected, Watertube, Spreader Stoker
HSC-400		400	Field-Erected, Watertube, Pulverized Feed
LSC-30	Low-Sulfur Coal	30	Package, Watertube, Underfeed Stoker
LSC-75		75	Field-Erected, Watertube, Underfeed Stoker
LSC-150		150	Field-Erected, Watertube, Spreader Stoker
LSC-400		400	Field-Erected, Watertube, Pulverized Feed

electrostatic precipitators, fabric filters, dual alkali scrubbers, dry scrubbers (spray dryers) and sodium throwaway scrubbers. These controls were selected because they are the most likely candidates to control SO_2 and PM emissions on new industrial boilers.

SO_2 control devices can be equipped to remove both SO_2 and PM. Dual alkali scrubbing systems can be designed to remove both PM and SO_2 or SO_2 only depending on whether additional PM control equipment is included prior to the scrubber. In addition, sodium throwaway scrubbers can remove both SO_2 and PM or SO_2 alone. However, since a fabric filter is a integral part of dry scrubbing systems, all of these systems are designed for combined SO_2 and PM control. Details of the control device specifications will be presented in Section 2.3.

Dual alkali scrubbers and sodium throwaway scrubbers are analyzed at both 50 and 90 percent SO_2 removal. Dry scrubbers are analyzed only at 50 percent SO_2 removal on low sulfur coal-fired boilers.

As stated earlier, a controlled standard boiler is termed a model boiler. The standard boilers used in this cost analysis were presented in Table 2-1. The model boilers formed from the combination of the standard boilers and the PM and SO_2 controls are presented in Tables 2-2, 2-3, and 2-4. Abbreviations used in these tables are defined in Table 2-5. Tables 2-2 through 2-4 also present the PM and SO_2 emission levels that these controls can achieve for each model boiler case. These emission levels or percent reductions are based on available emission test data.[1]

2.2 COST CALCULATION APPROACH

The costs of each model boiler can be broken down into three major cost categories:

- Capital Costs (total capital investment required to construct and make operational a boiler and control system),
- Operation and Maintenance (O&M) costs (total annual cost necessary to operate and maintain a boiler and control system), and
- Annualized Costs (total O&M costs plus capital related charges).

TABLE 2-2. HIGH SULFUR COAL-FIRED MODEL BOILERS FOR SO_2 and PM CONTROLS

Model Boiler	Controlled Emissions ($lb/10^6$ Btu)		Removal Efficiencies (Percent)	
	SO_2	PM	SO_2	PM
HSC-30-Unc, Unc	5.70	0.657	0	0
HSC-30-Unc, SM	5.70	0.40	0	39.1
HSC-30-Unc, SSS	5.70	0.20	0	69.6
HSC-30-Unc, VS	5.70	0.10	0	84.8
HSC-30-Unc, ESP	5.70	0.05	0	92.4
HSC-30-DA(50), DA/PM	2.85	0.10	50	84.8
HSC-30-DA(50), ESP	2.85	0.05	50	92.4
HSC-30-DA(90), DA/PM	0.57	0.10	90	84.8
HSC-30-DA(90), ESP	0.57	0.05	90	92.4
HSC-75-Unc, Unc	5.70	0.657	0	0
HSC-75-Unc, SM	5.70	0.40	0	39.1
HSC-75-Unc, SSS	5.70	0.20	0	69.6
HSC-75-Unc, VS	5.70	0.10	0	84.8
HSC-75-Unc, ESP	5.70	0.05	0	92.4
HSC-75-DA(50), DA/PM	2.85	0.10	50	84.8
HSC-75-DA(50), ESP	2.85	0.05	50	92.4
HSC-75-DA(90), DA/PM	0.57	0.10	90	84.8
HSC-75-DA(90), ESP	0.57	0.05	90	92.4
HSC-150-Unc, Unc	5.70	2.54	0	0
HSC-150-Unc, SM	5.70	0.60	0	76.4
HSC-150-Unc, SSS	5.70	0.20	0	92.1
HSC-150-Unc, VS	5.70	0.10	0	96.1
HSC-150-Unc, ESP	5.70	0.05	0	98.0
HSC-150-DA(50), DA/PM	2.85	0.10	50	96.1
HSC-150-DA(50), ESP	2.85	0.05	50	98.0
HSC-150-DA(90), DA/PM	0.57	0.10	90	96.1
HSC-150-DA(90), ESP	0.57	0.05	90	98.0
HSC-400-Unc, Unc	5.70	3.81	0	0
HSC-400-Unc, SM	5.70	1.00	0	73.8
HSC-400-Unc, SSS	5.70	0.20	0	94.8
HSC-400-Unc, VS	5.70	0.10	0	97.4
HSC-400-Unc, ESP	5.70	0.05	0	98.7
HSC-400-DA(50), DA/PM	2.85	0.10	50	97.4
HSC-400-DA(50), ESP	2.85	0.05	50	98.7
HSC-400-DA(90), DA/PM	0.57	0.10	90	97.4
HSC-400-DA(90), ESP	0.57	0.05	90	98.7

TABLE 2-3. LOW SULFUR COAL-FIRED MODEL BOILERS FOR SO_2 and PM CONTROLS

Model Boiler	Controlled Emissions ($lb/10^6$ Btu)		Removal Efficiencies (Percent)	
	SO_2	PM	SO_2	PM
LSC-30-Unc, Unc	1.19	0.807	0	0
LSC-30-Unc, SM	1.19	0.40	0	50.0
LSC-30-Unc, SSS	1.19	0.20	0	75.2
LSC-30-Unc, VS	1.19	0.10	0	87.6
LSC-30-Unc, FF	1.19	0.05	0	93.8
LSC-30-DS(50), DS/PM	0.595	0.10	50	87.6
LSC-30-DA(50), DA/PM	0.595	0.10	50	87.6
LSC-30-DA(50), FF	0.595	0.05	50	93.8
LSC-30-DA(90), DA/PM	0.119	0.10	90	87.6
LSC-30-DA(90), FF	0.119	0.05	90	93.8
LSC-75-Unc, Unc	1.19	0.807	0	0
LSC-75-Unc, SM	1.19	0.40	0	50.0
LSC-75-Unc, SSS	1.19	0.20	0	75.2
LSC-75-Unc, VS	1.19	0.10	0	87.6
LSC-75-Unc, FF	1.19	0.05	0	93.8
LSC-75-DS(50), DS/PM	0.595	0.10	50	87.6
LSC-75-DA(50), DA/PM	0.595	0.10	50	87.6
LSC-75-DA(50), FF	0.595	0.05	50	93.8
LSC-75-DA(90), DA/PM	0.119	0.10	90	87.6
LSC-75-DA(90), FF	0.119	0.05	90	93.8
LSC-150-Unc, Unc	1.19	3.13	0	0
LSC-150-Unc, SM	1.19	0.6	0	80.8
LSC-150-Unc, SSS	1.19	0.20	0	93.6
LSC-150-Unc, VS	1.19	0.10	0	96.8
LSC-150-Unc, FF	1.19	0.05	0	98.4
LSC-150-DS(50), DS/PM	0.595	0.10	50	96.8
LSC-150-DA(50), DA/PM	0.595	0.10	50	96.8
LSC-150-DA(50), FF	0.595	0.05	50	98.4
LSC-150-DA(90), DA/PM	0.119	0.10	90	96.8
LSC-150-DA(90), FF	0.119	0.05	90	98.4
LSC-400-Unc, Unc	1.19	2.39	0	0
LSC-400-Unc, SM	1.19	1.0	0	58.2
LSC-400-Unc, SSS	1.19	0.20	0	91.6
LSC-400-Unc, VS	1.19	0.10	0	95.8
LSC-400-Unc, FF	1.19	0.05	0	97.9
LSC-400-DS(50), DS/PM	0.595	0.10	50	95.8
LSC-400-DA(50), DA/PM	0.595	0.10	50	95.8
LSC-400-DA(50), FF	0.595	0.05	50	97.9
LSC-400-DA(90), DA/PM	0.119	0.10	90	95.8
LSC-400-DA(90), FF	0.119	0.05	90	97.9

TABLE 2-4. RESIDUAL OIL-FIRED MODEL BOILERS FOR SO_2 AND PM CONTROLS

Model Boiler	Controlled Emissions ($lb/10^6$ Btu)		Removal Efficiencies (Percent)	
	SO_2	PM	SO_2	PM
RES-30-Unc, Unc	3.21	0.23	0	0
RES-30-Unc, ESP	3.21	0.05	0	78.3
RES-30-NATH(50), NATH/PM	1.61	0.10	50	56.5
RES-30-NATH(50), ESP	1.61	0.05	50	78.3
RES-30-NATH(90), NATH/PM	0.321	0.10	90	56.5
RES-30-NATH(90), ESP	0.321	0.05	90	78.3
RES-30-DA(90), DA/PM	0.321	0.10	90	56.5
RES-30-DA(90), ESP	0.321	0.05	90	78.3
RES-150-Unc, Unc	3.21	0.23	0	0
RES-150-Unc, ESP	3.21	0.05	0	78.3
RES-150-DA(50), DA/PM	1.61	0.10	50	56.5
RES-150-DA(50), ESP	1.61	0.05	50	78.3
RES-150-DA(90), DA/PM	0.321	0.10	90	56.5
RES-150-DA(90), ESP	0.321	0.05	90	78.3

TABLE 2-5. ABBREVIATIONS USED FOR MODEL BOILERS

Boilers

HSC - High sulfur coal-fired
LSC - Low sulfur coal-fired
RES - Residual oil-fired

PM Control Systems

Unc - Uncontrolled
SM - Single mechanical collector (multitube cyclone)
SSS - Sidestream separator
ESP - Electrostatic precipitator
FF - Fabric filter
DA/PM - Particulate removal via dual alkali scrubber
DS/PM - Particulate removal via dry scrubber
NATH/PM - Particulate removal via sodium throwaway scrubber

SO_2 Control Systems

Unc - Uncontrolled
DA (50) - Dual alkali scrubber (50 percent removal)
DA (90) - Dual alkali scrubber (90 percent removal)
DS (50) - Dry scrubber (spray dryer) (50 percent removal)
NATH (50) - Sodium throwaway scrubber (50 percent removal)
NATH (90) - Sodium throwaway scrubber (90 percent removal)

Each of these cost categories can be further subdivided into individual cost components. Sections 2.2.1, 2.2.2, and 2.2.3 present the individual cost components and the methods used to develop the capital, O&M, and annualized costs, respectively for each of the model boilers.

The majority of the capital and O&M cost components for the boilers, SO_2 controls and PM controls are estimated by the use of cost algorithms. Each algorithm presents a particular boiler or control device cost component as an algebraic function of key system specifications. Table 2-6 summarizes the costing algorithms available. The routine codes shown in the first column of Table 2-6 identify the algorithms in the FORTRAN computer program that is used to develop the costs presented in this report. A complete listing of the algorithms is presented in Appendix A while a complete listing of the FORTRAN computer program is presented in Appendix B.

2.2.1 Capital Costs

Table 2-7 presents the individual capital cost components and the general methodology used for calculating total capital costs. Direct capital costs consist of the basic and auxiliary equipment costs in addition to the labor and material required to install the equipment. Indirect costs are those costs not attributable to specific equipment items. Other capital cost components are contingencies, the cost of land and working capital.

Contingencies are included in capital costs to compensate for unpredicted events and other unforeseen expenses. Costs for land are included in boiler capital costs but not in control system costs. All boilers except pulverized coal boilers are assumed to have land costs of $2,000. Pulverized coal boilers are assumed to have land costs of $4,000.

The computation of working capital in this analysis also differs slightly for boilers and control equipment. In calculating the cost for working capital the equations shown in Table 2-8 are used. These equations are based on three months of direct annual non-fuel operating costs and one month of fuel costs.

Most cost algorithms compute the key individual capital cost components (equipment costs, installation costs and indirect costs). However, some of the algorithms used in this analysis deviate from this methodology. For

TABLE 2-6. SUMMARY OF PM AND SO_2 COSTING ALGORITHMS

Routine Code[a]	Algorithm Type	Boiler Size Applicability (10^6 Btu/hr)
UNDR	Boiler, underfeed stoker, watertube, package	≤ 75
SPRD	Boiler, spreader stoker, watertube, field-erected	60 - 200
PLVR	Boiler, pulverized coal, watertube, field-erected	≥ 200
RES1	Boiler, residual oil, firetube, package	≤ 30
RNG1	Boiler, residual/natural gas, watertube, package	30 - 200
RNG2	Boiler, residual/natural gas, watertube, field-erected	200 - 700
DNG1	Boiler, distillate/natural gas, firetube, package	≤ 30
DNG2	Boiler, distillate/natural gas, watertube, package	30 - 200
VS	Venturi scrubber applied to coal-fired boiler	30 - 700
ESPC	Electrostatic precipitator applied to coal-fired boiler	≤ 700
ESPO	Electrostatic precipitator applied to residual oil-fired boiler	≤ 700
FF	Fabric filter applied to coal-fired boiler	30 - 700
SM	Single mechanical collector (multi-cyclone) applied to coal-fired boiler	30 - 700
DM	Dual mechanical collector (multi-cyclones) applied to coal-fired boiler	30 - 700
SSS	Side stream separator applied to coal-fired boiler	30 - 700
DA	Dual alkali FGD system without PM removal	All sizes
DAC	Dual alkali FGD system with PM removal	All sizes
NATH	Sodium throwaway FGD system	All sizes
DS	Lime spray drying (dry scrubbing) FGD system	All sizes

[a] Routine code refers to code used to identify algorithm in FORTRAN computer program (see Appendix B).

TABLE 2-7. CAPITAL COST COMPONENTS[a]

---

(1) Direct Costs

Equipment
+ Installation
= Total Direct Costs

(2) Indirect Costs

Engineering - 10% of direct costs for boilers and PM controls[2]

For FGD systems on boilers $\leq 200 \times 10^6$ Btu/hr, FGD engineering costs are 10% of FGD direct costs for an FGD system that is applied to a 200×10^6 Btu/hr boiler.

For FGD systems on boilers $\geq 200 \times 10^6$ Btu/hr, FGD engineering costs are 10% of specific FGD system's direct costs.[13]

\+ Construction and Field Expenses	(10% of direct costs)[2]
\+ Construction Fees	(10% of direct costs)[2]
\+ Start Up Costs	(2% of direct costs)[2]
\+ Performance Costs	(1% of direct costs)[13]
= Total Indirect Costs	

(3) Contingencies[2] = 20% of (Total Indirect + Total Direct Costs)

(4) Total Turnkey Cost = Total Indirect Cost + Total Direct Cost + Contingencies

(5) Working Capital[2] = 25% of Total Direct Operating Costs[b]

(6) Land[c]

(7) Total Capital Cost = Total Turnkey + Working Capital + Land

---

[a] Boiler and each control system costed separately; factors apply to cost of boiler or control system considered; i.e., the engineering cost for the PM control system is 10% of the direct cost of the PM control system.

[b] This equation is used for control device working capital calculations. For boilers, fuel supplies are included so a different equation is used (see Table 2-8).

[c] Land costs are assumed to apply to boilers only (see Section 2.2.1).

TABLE 2-8. WORKING CAPITAL CALCULATIONS FOR BOILERS AND CONTROL DEVICES

Working Capital (WC)

Boilers - Assume three months of direct annual non-fuel operating costs and one month of fuel costs

$WC^4 = 0.25$ (Direct annual non-fuel operating costs) + 0.083 (Fuel costs)

Control Equipment - Assume three months of direct annual operating costs

$WC^2 = 0.25$ (Direct annual operating costs) example, FGD algorithms compute total direct costs without prior computation of equipment and installation costs. Also, in certain cases, indirect capital costs, as shown in Table 2-7, are computed as a percentage of the direct costs.

2.2.2 Operation and Maintenance (O&M) Costs

Table 2-9 lists the individual O&M cost components and the general methodologies used in calculating total O&M costs. Direct O&M costs include operating and maintenance labor, fuel, utilities, spare parts, supplies, waste disposal and chemicals. Indirect operating costs include payroll and plant overhead and are calculated based on a percentage of some key O&M cost components (direct labor, supervisory labor, maintenance labor and spare parts).

Direct O&M costs for the boilers and control devices are calculated by using the algorithms presented in Appendix A. The key factors in these algorithms are the capacity utilization, utility unit costs (steam electricity, water), and unit costs for raw materials, waste disposal, and labor.

Capacity utilization is defined as the actual annual fuel consumption as a percentage of the potential annual fuel consumption at maximum firing rate. To account for reduced labor costs for boilers operating at reduced capacity utilization, labor factors that are based on capacity utilization are used. Table 2-10 presents the capacity utilizations and labor factor functions used for the boiler and control device O&M cost calculations.

Table 2-11 presents the unit costs used in calculating several of the other key annual O&M cost components for the boilers and control equipment. Some additional factors affecting O&M costs are boiler type, boiler size, fuel type, fuel composition, flue gas flowrate, and control efficiency (see Appendix A).

2.2.3 Annualized Costs

Total annualized costs are the sum of the annual O&M costs and the annualized capital charges. The annualized capital charges include the payoff of the capital investment (capital recovery), interest on working capital, general and administrative costs, taxes, and insurance.

TABLE 2-9. OPERATING AND MAINTENANCE COST COMPONENTS[a]

(1) Direct Operating Costs

Direct Labor
+ Supervision
+ Maintenance Labor, Replacement Parts and Supplies
+ Electricity
+ Water
+ Steam
+ Waste Disposal
  Solids (Fly ash and bottom ash)
  Sludge
  Liquid
+ Chemicals

Total Non-Fuel O&M
+ Fuel

= Total Direct Operating Costs

(2) Indirect Operating Costs (Overhead)[b]

Payroll (30% Direct Labor)
+ Plant (26% of Direct Labor + Supervision + Maintenance Costs + Spare Parts)

(3) Total Annual Operating and Maintenance Costs = Total Direct + Total Indirect Costs

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[a] Boilers and each control systems are costed separately; factors apply to boiler or control system being considered, (i.e., payroll overhead for FGD system is 30% direct labor requirement of FGD system).

[b] Factors recommended in Reference 3.

TABLE 2-10. CAPACITY UTILIZATION AND LABOR FACTORS USED FOR MODEL BOILER COST CALCULATIONS

Boiler Type	Capacity Utilization (CF)	Labor Factor (LF)
Coal-fired (Underfeed, spreader stoker, pulverized feed)	0.60	0.75
Residual oil-fired	0.55	0.62

Labor Factor Equations[4]

CF	LF
>0.7	1
0.5 - 0.7	0.5 + 2.5 (CF - 0.5)
<0.5	0.5

TABLE 2-11. UNIT COSTS USED IN CALCULATIONS[a,b]

Utilities	
Electricity	\$0.0258/kwh
Water	\$0.04/m^3 (\$0.15/10^3 gal)
Steam	\$3.01/GJ (\$3.5/10^3 lb)
Raw Material	
Na_2CO_3	\$0.099/kg (\$90/ton)
Lime	\$0.039/kg (\$35/ton)
Limestone	\$0.009/kg (\$8/ton)
Labor	
Direct Labor	\$12.02/man-hour
Supervision	\$15.63/man-hour
Maintenance Labor	\$14.63/man-hour
Waste Disposal	
Solids (Ash, Spray Dried Solids)	\$0.166/kg (\$15/ton)
Sludge	\$0.0166/kg (\$15/ton)
Liquid	\$0.47/m^3 (\$1.80/10^3 gal)

[a] All costs in 1978 \$.

[b] Reference 2.

Table 2-12 presents the methods used in this report to calculate the individual annualized capital charges components. The capital recovery cost is determined by multiplying the capital recovery factor, which is based on the real interest rate and the equipment life, by the total turnkey costs (see Table 2-7). For this analysis a 10 percent real interest rate and a 15 year equipment are assumed for the boilers and control equipment. This translates into a capital recovery factor of 13.15 percent. The real interest rate of 10 percent was selected as a typical constant dollar rate of return on investment to provide a basis for calculation of capital recovery charges. Since all costs presented in this report are constant mid-1978 dollars, this interest rate is the "real" interest rate above and beyond inflation (see Appendix D for cost conversions due to inflation).

Table 2-12 also presents the methods to calculate the other annualized capital charges components. Interest on working capital is based on a 10 percent interest rate. The remaining components (general and administrative costs, taxes, and insurance) are estimated as 4 percent of total turnkey costs.

2.3 BOILER AND FUEL COSTS

This section presents the specific cost assumptions and methodologies that were used to calculate the industrial boiler costs presented in Chapters 3 and 4. The general costing assumptions and methodologies were presented in Section 2.2. The capital and annual O&M cost algorithms for coal-, oil-, and gas-fired industrial boilers are presented in Appendix A (Tables A-4 through A-11). Specific equipment lists and assumptions used to generate the algorithms are detailed in References 5 and 6.

All boiler costs are based on a new boiler constructed at a new plant in the Midwest and do not include any retrofit costs. It is assumed that new plants will operate multiple boilers rather than one boiler. Annual O&M costs such as labor, utilities, chemicals, spare parts and ash disposal will be reduced per boiler because of the economies of scale. To account for the O&M cost reductions associated with multiple boiler installations,

TABLE 2-12. ANNUALIZED COST COMPONENTS

(1) Total Annualized Cost = Annual Operating Costs + Capital Charges

(2) Capital Charges = Capital recovery + interest on working capital + miscellaneous (G&A, taxes and insurance)

(3) Calculation of Capital Charges Components

A. Capital Recovery = Capital Recovery Factor (CRF) x Total Turnkey Cost

$$CRF = \frac{i\,(1+i)^n}{(1+i)^n - 1}$$

i = interest rate

n = number of years of useful life of boiler or control system

Item	n	i	CRF
Boiler, control systems	15	10	0.1315

B. Interest on Working Capital = 10% of working capital

C. G&A, taxes and insurance = 4% of total turnkey cost multipliers for the annual O&M costs are included in the algorithms. These multipliers are presented in Table 2-13.

The boiler specifications presented in Tables 2-14 and 2-15 provide the specifications required to calculate the boiler capital costs presented in this report. Coal-fired units with less than 60 x 10^6 Btu/hr thermal input capacity and oil- and gas-fired units with less than 200 x 10^6 Btu/hr capacity are specified to be package boilers while all other boilers are assumed to be field-erected units. It is also assumed that all boilers are operating under low excess air firing conditions. The flue gas flow rates presented were calculated from the algorithms presented in Appendix A (Table A-23).

The largest O&M cost for boilers is fuel. Table 2-16 presents the specifications and costs for the fuels used in this analysis. The fuel costs presented are consistent with the 1990 delivered fuel price projections (in 1978 dollars) used in the Industrial Fuel Choice Analysis Model (IFCAM). The IFCAM documentation is the source of the coal transportation costs, while the Round 8 Impact Analysis is the basis for fuel prices.[7,8]

2.4 PARTICULATE MATTER (PM) CONTROL COSTS

The algorithms used to calculate capital and operating costs for PM control devices are presented in Appendix A (Tables A-12 through A-18). The cost algorithms for electrostatic precipitators (ESPs), reverse air fabric filters, and venturi wet scrubbers were developed by PEDCo, Inc. Detailed documentation of the cost bases for these controls can be found in PEDCo's final report.[11] The costs for single mechanical collectors and side stream separators were developed by Radian based primarily on vendor information. Documentation of these costs can be found in a technical note and attachments.[12]

Table 2-17 lists the general specifications for the PM control devices investigated. These specifications are typical for industrial boiler control devices currently in use.

TABLE 2-13. DIRECT O&M COST MULTIPLIERS TO ACCOUNT FOR ECONOMIES ASSOCIATED WITH MULTIPLE BOILER INSTALLATIONS[4]

	Multiplier
Coal-fired boilers:	
Utilities, chemicals, and ash disposal	0.848
All labor, replacement parts, and overhead	0.767
Residual oil-fired boilers:	
Utilities and chemicals	0.845
All labor, replacement parts, and overhead	0.799

TABLE 2-14. SPECIFICATIONS FOR COAL-FIRED STANDARD BOILERS

	HSC-30	HSC-75	HSC-150	HSC-400	LSC-30	LSC-75	LSC-150	LSC-400
Thermal input 10^6 Btu/hr	30	75	150	400	30	75	150	400
Fuel firing method	Under feed	Under feed	Spreader stoker	Pulverized feed	Under feed	Under feed	Spreader stoker	Pulverized feed
Excess air, %	35	35	35	35	35	35	35	35
Flue gas flow rate, acfm	11000	27600	55100	142000	11300	28300	56700	146000
Capacity utilization, %	60	60	60	60	60	60	60	60
Efficiency, %	78.0	79.9	80.9	83.1	78.3	80.5	81.5	83.5
Steam production, lb/hr	22700	58200	107000	280000	22800	58800	108044	279200

TABLE 2-15. SPECIFICATIONS FOR RESIDUAL OIL-FIRED STANDARD BOILERS

	RES-30	RES-150
Thermal Input, 10^6 Btu/hr	30	150
Excess air, %	15	15
Flue gas flow rate, acfm	9010	45000
Capacity Utilization, %	55	55
Efficiency, %	85	85
Steam production, lb/hr	25000	108000

TABLE 2-16. FUEL ANALYSIS AND PRICES[a,b]

Fuel Type	Heating Value Btu/lb	Sulfur Content	Moisture Content	Ash Content	1990 Delivered Fuel Cost $/10^6 Btu (1978 $)
		% by weight			
High sulfur coal	11,800	3.54	8.79	10.54	1.81
Low sulfur coal	9,600	0.60	20.80	5.40	2.41
Residual oil	18,500	3.00	0.08	0.10	4.85

[a] All analyses are based on engineering judgements by PEDCo about information provided by Babcock and Wilcox, References 9 and 10.

[b] All costs are projected 1990 costs in 1978 dollars. Fuel costs are based on the Industrial Fuel Choice Analysis Model (IFCAM) costs.[7,8]

TABLE 2-17. GENERAL DESIGN SPECIFICATIONS FOR PM CONTROL SYSTEMS

Control Device	Item	Specification
Single Mechanical Collectors (SM)	Material of construction	Carbon steel
	Pressure drop[a]	4 in. H_2O gauge
Side Stream Separators (SSS)	Material of construction	Mechanical collector and fabric filter: carbon steel
	Pressure drop[a]	6 in. H_2O gauge
	Amount of gas flow treated in fabric filter	20%
	Fabric filter	Multi-compartment pulse-jet with Teflon coated glass felt bags
	Bag life	2 years
Venturi Scrubbers (VS)	Components	Hold tank, recirculation system, and purge stream piping
	Pressure drop[b]	20 in. H_2O gauge
	Sludge treatment	Scrubber sludge added to coal pile runoff treatment system

TABLE 2-17. (CONTINUED)

Control Device	Item	Specification
Electrostatic Precipitators (ESP)	Material of construction	Carbon steel (insulated)
	Specific collection areas[c] (plate area per gas volume for 0.05 lb/10^6 Btu control levels)	Underfeed stokers: 117.3 $ft^2/10^3$ acfm Spreader stokers: 189.3 $ft^2/10^3$ acfm Pulverized Coal: 220 $ft^2/10^3$ acfm Oil-fired: 400 $ft^2/10^3$ acfm
	Pressure drop[a]	1 in. H_2O gauge
	Power demand	3 W/ft^2
Fabric Filter (FF)	Material of construction	Carbon steel (insulated)
	Cleaning method	Reverse-air (multi-compartment)
	Air to cloth ratio	2 ft/min
	Bag material	Teflon-coated fiberglass
	Bag life	2 years
	Pressure drop[a]	6 in. H_2O gauge

[a] Pressure drop refers to gas side pressure drop across entire control system.

[b] Pressure drop for variable throat venturi scrubber will vary with required removal efficiency. Maximum pressure drop of 20 in. H_2O was assumed for estimating fan costs.

[c] Values shown are for sulfur content of 3.5% in coal feed to boiler. Boilers firing coals with lower sulfur content have somewhat higher SCA values.

2.5 SO_2 CONTROL COSTS

The cost algorithms used to calculate capital and annual operating costs for flue gas desulfurization units are also presented in Appendix A (Tables A-19 through A-22). The cost basis for the double alkali without PM removal, lime spray drying, and once through sodium systems is presented in the Individual Technology Assessment Report (ITAR).[13] Cost algorithms based on the ITAR were developed by Acurex Corporation.[14] The algorithms presented in Appendix A however, do not represent the costs in the final ITAR or the Acurex report for either the double alkali or spray drying systems. The Acurex algorithms were revised to reflect revised clarifier costs for the double alkali systems and revised fabric filter costs for the spray drying systems. These revisions are documented in a technical memo.[11] The sodium throwaway cost algorithms are unchanged from the Acurex report. Costs for the double alkali system designed to remove PM as well as SO_2 were developed by Radian and include a venturi-type scrubber and a single mechanical collector upstream of the scrubber.[15] The costs for the double alkali system design without PM removal is based on the use of a tray-type scrubber.

Table 2-18 presents the general specifications for the FGD systems analyzed in this report. These specifications are typical for FGD systems currently in use.

2.6 COMPLIANCE, REPORTING, AND MALFUNCTION COSTS

Table 2-19 presents estimates for compliance, reporting, and control device malfunction costs based on issue papers prepared by Radian.[16,17,18] These costs vary with boiler size and type of control system.

Annual reporting costs for units without FGD reflect "baseline" requirements specified for all new sources; start-up, shutdown, and malfunction reports. It was assumed that units with FGD would also be required to make a quarterly excess emissions report, estimated to add about $2000 to the baseline cost of $4800 to $5000.

Units with FGD were assumed to require continuous monitors for inlet and outlet SO_2 and a diluent (CO_2 or O_2) monitor. Continuous NO_x monitoring

TABLE 2-18. GENERAL DESIGN SPECIFICATIONS FOR SO_2 CONTROL SYSTEMS

Control Device	Item	Specification
Double Alkali FGD (SO_2 removal only) (DA)	Scrubber type	Tray tower
	Pressure drop[a]	8 in. H_2O gauge
	L/G	10 gal/10^3 acf
	Scrubber sludge	60% solids
	Sludge disposal	Trucked to off-site landfill
Sodium Throwaway FGD (either SO_2 removal only or combined SO_2 & PM removal) (NATH)	Material of construction	316 stainless steel
	Scrubber type	Variable throat venturi
	Pressure drop[a]	8 in. H_2O gauge
	L/G	10 gal/10^3 acf
	Wastewater treatment	Treated in existing facility
Double Alkali FGD (SO_2 and PM removal) (DA)	Material of construction	316 stainless steel
	Scrubber type	Variable throat venturi
	System design	Includes 80% efficient single mechanical collector upstream of scrubber

TABLE 2-18. (CONTINUED)

(continued) Double Alkali FGD (SO_2 and PM removal)	Pressure drop[a] (over SM and scrubber)	20 in. H_2O gauge
	L/G	10 gal/10^3 acf
	Sludge disposal	Dry particulate collected in single mechanical combined with 60% solids scrubber sludge and trucked to off-site landfill
Dry Scrubbing (spray drying, SO_2 and PM removal) (DS)	Material of construction	Carbon steel spray dryer and fabric filter (insulated)
	Reagent	Lime; no solids recycle
	Fabric filter	Reverse-air (same design as previous fabric filter)
	Pressure drop[a]	6 in. H_2O gauge
	L/G	0.3 gal/acf
	Solids disposal	Trucked to off-site landfill

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[a] All pressure drops refer to gas side pressure drop across entire control system.

TABLE 2-19. ANNUAL REPORTING, COMPLIANCE, AND MALFUNCTION COSTS

REPORTING[a]

For units with FGD:

Baseline Annual:	\$4800
Quarterly Excess Emissions:	+ \$1920
	\$6720

For units without FGD:

Baseline Annual:	\$4800

COMPLIANCE

For units with FGD:

(Continuous) Inlet SO_2	\$63,000	
(Continuous) Outlet SO_2		
Diluent (O_2/CO_2)		
Opacity[b]	+ \$10,800	
Continuous NO_x (≥250 x 10^6 Btu/hr only)		+ \$30,800
NO_x Method 7/O_2 (<250 x 10^6 Btu/hr only)		+ \$12,000
Total for ≥250 x 10^6 Btu/hr w/FGD =		\$105,000
Total for <250 x 10^6 Btu/hr w/FGD =		\$86,000

For units without FGD: (<250 x 10^6 Btu/hr)

Method 5 (PM	\$10,000
Opacity[b]	+ \$10,800
Method 7 (NO_x)	+ \$ 5,000
Continuous O_2	+ \$17,700
	\$45,500

MALFUNCTION (for units with FGD only)

Assuming 5% downtime (of FGD system) during which oil is fired. Oil/Coal fuel cost differential - \$3/10^6 Btu. (FGD operating costs do not reflect downtime. They are calculated on the basis of 100 percent FGD system availability).

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[a] Baseline costs are for general provisions requirements for reporting start-up, shutdown, and malfunction.

[b] Pressure drop meter instead of opacity meter for boilers with combined SO_2/PM scrubbing or PM wet scrubbing.

was assumed for units with thermal input capacities greater than 250 x 10^6 Btu/hr. Units less than 250 x 10^6 Btu/hr were assumed to combine an annual Method 5 and Method 7 tests and continuous O_2 monitoring. All boilers were assumed to require an opacity monitor (or a pressure drop meter for boilers equipped with wet scrubbers for PM or combined PM/SO_2 removal). Malfunction costs are based on the use of low sulfur oil for a downtime period of 5 percent of the total boiler operating hours.

Compliance, reporting, and malfunction costs are not included in the total costs presented in subsequent chapters. The costs presented in Table 2-19 are considered typical of those that might be associated with various regulatory alternatives. However, the requirements of specific regulations will determine the actual costs incurred.

2.7 REFERENCES

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3.0 COSTS OF PM AND SO_2 CONTROL FOR COAL-FIRED BOILERS

This section presents the results of the model boiler cost analysis for various PM and SO_2 control technologies applied to coal-fired boilers. This analysis focuses on the capital cost, annual O&M costs, and total annualized cost of control for both HSC and LSC-fired units between 30 x 10^6 Btu/hr and 400 x 10^6 Btu/hr capacity.

Five technologies which control only PM are examined:

- single mechanical collector (SM),
- side stream separator (SSS),
- venturi scrubber (VS),
- electrostatic precipitator (ESP), and
- fabric filter (FF).

The ESP systems are applied to the HSC-fired units while the FF systems are used on the LSC-fired units. This analysis indicates little or no cost advantage for ESP systems compared to FF systems for HSC-fired boilers. Since the costs of FF's are relatively insensitive to fuel properties, the costs for FF's applied to LSC-fired units presented here are believed to be representative of costs for FF's applied to HSC-fired boilers.

Four SO_2 control technologies are also examined:

- dual alkali FGD scrubbing without provisions for PM removal (tray type scrubber),
- dual alkali FGD scrubbing with provisions for PM removal (venturi scrubber),
- lime spray drying FGD (includes a fabric filter), and
- sodium throwaway FGD scrubbing.

The first two technologies are analyzed for both HSC- and LSC-fired units at 50 percent and 90 percent SO_2 removal levels. The lime spray drying system is analyzed at a 50 percent removal level for LSC-fired units only. Sodium throwaway scrubbing is examined for small residual oil-fired units.

All costs in this chapter are presented as 1978 dollars. Coal-fired and residual oil-fired boilers are assumed to have a capacity utilization of 0.6 and 0.55, respectively. All boilers and control equipment are assumed to have a capital recovery factor of 13.15 percent which is based on an equipment life of 15 years and a real interest rate of 10 percent.

This chapter is divided into two sections. The first discusses capital costs while the second discusses annual O&M and total annualized costs.

3.1 CAPITAL COSTS OF PM AND SO_2 CONTROLS APPLIED TO COAL-FIRED BOILERS

Tables 3-1 and 3-2 present capital costs for the HSC- and LSC-fired model boilers defined in Chapter 2. The normalized capital costs provide a size independent measure of the capital required to build a boiler and associated pollution control system. This value estimates the capital ($1000) required per unit of installed heat input capacity (10^6 Btu/hr).

These normalized costs are graphically depicted in Figures 3-1 and 3-2. The larger boilers in the size range presented, 150-400 x 10^6 Btu/hr, do not show the steady decrease in capital costs as expected. This is due to the fact that these boilers are spreader stoker and pulverized feed units and are more complex and capital intensive than the underfeed boilers used in the smaller boiler sizes (30 and 75 x 10^6 Btu/hr).

Also included in Tables 3-1 and 3-2 is the percent increase in capital costs over the uncontrolled model boiler. This data is graphically illustrated in Figures 3-3 and 3-4 for HSC- and LSC-fired model boilers, respectively. Of immediate note is the higher percent increases for HSC-fired units compared to LSC-fired units for the same pollution control systems. The result is due to the lower uncontrolled SO_2 and PM emissions inherent in the burning of LSC. The net result is a reduction in the costs of FGD and PM control systems and lower percent increases over the uncontrolled case for LSC-fired units. Also, the uncontrolled LSC-fired model boilers tend to have higher capital costs than HSC-fired units due to higher working capital requirements associated with the use of more expensive LSC fuel. (See Tables 2-7 and 2-8 for calculation of capital costs and working capital.)

TABLE 3-1. CAPITAL COSTS FOR HSC-FIRED MODEL BOILERS

Model Boiler	Capital Costs ($1000)					
	Uncontrolled Boiler	SO_2 Control	PM Control	Total	Normalized Total[a]	% Increase Over Uncontrolled
HSC-30-Unc, Unc	1857	0	0	1857	61.9	0
HSC-30-Unc, SM	1857	0	60	1917	63.9	3.2
HSC-30-Unc, SSS	1857	0	105	1962	65.4	5.7
HSC-30-Unc, VS	1857	0	143	2000	66.7	7.7
HSC-30-Unc, ESP	1857	0	225	2082	69.4	12.1
HSC-30-DA(50), DA/PM	1857	862	w/SO_2	2719	90.6	46.4
HSC-30-DA(50), ESP	1857	721	225	2803	93.4	50.9
HSC-30-DA(90), DA/PM	1857	959.	w/SO_2	2816	93.9	51.6
HSC-30-DA(90), ESP	1857	829	225	2911	97.0	56.8
HSC-75-Unc, Unc	3380	0	0	3380	45.1	0
HSC-75-Unc, SM	3380	0	118	3498	46.6	3.5
HSC-75-Unc, SSS	3380	0	214	3594	47.9	6.3
HSC-75-Unc, VS	3380	0	252	3632	48.4	7.5
HSC-75-Unc, ESP	3380	0	407	3787	50.5	12.0
HSC-75-DA(50), DA/PM	3380	1183	w/SO_2	4563	60.8	35.0
HSC-75-DA(50), ESP	3380	1042	407	4829	64.4	42.9
HSC-75-DA(90), DA/PM	3380	1316	w/SO_2	4696	62.6	38.9
HSC-75-DA(90), ESP	3380	1202	407	4989	66.5	47.6
HSC-150-Unc, Unc	7737	0	0	7737	51.6	0
HSC-150-Unc, SM	7737	0	201	7938	52.9	2.6
HSC-150-Unc, SSS	7737	0	370	8107	54.0	4.8
HSC-150-Unc, VS	7737	0	436	8173	54.5	5.6
HSC-150-Unc, ESP	7737	0	1222	8959	59.7	15.8
HSC-150-DA(50), DA/PM	7737	1599	w/SO_2	9336	62.2	20.7
HSC-150-DA(50), ESP	7737	1407	1222	10366	69.1	34.0
HSC-150-DA(90), DA/PM	7737	1764	w/SO_2	9502	63.3	22.8
HSC-150-DA(90), ESP	7737	1625	1222	10584	70.6	36.8
HSC-400-Unc, Unc	18334	0	0	18334	45.8	0
HSC-400-Unc, SM	18334	0	414	18748	46.9	2.3
HSC-400-Unc, SSS	18334	0	784	19118	47.8	4.3
HSC-400-Unc, VS	18334	0	1012	19346	48.4	5.5
HSC-400-Unc, ESP	18334	0	1704	20038	50.1	9.3
HSC-400-DA(50), DA/PM	18334	2516	w/SO_2	20850	52.1	13.7
HSC-400-DA(50), ESP	18334	2230	1704	22268	55.7	21.5
HSC-400-DA(90), DA/PM	18334	2764	w/SO_2	21098	52.7	15.1
HSC-400-DA(90), ESP	18334	2576	1704	22614	56.5	23.3

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[a] Normalized total is total capital cost divided by boiler capacity ($1000/$10^6$ Btu/hr).

TABLE 3-2. CAPITAL COSTS FOR LSC-FIRED MODEL BOILERS

Model Boiler	Capital Costs ($1000) Uncontrolled Boiler	SO_2 Control	PM Control	Total	Normalized Total[a]	% Increase Over Uncontrolled
LSC-30-Unc, Unc	2244	0	0	2244	74.8	0
LSC-30-Unc, SM	2244	0	62	2306	76.9	2.8
LSC-30-Unc, SSS	2244	0	108	2352	78.4	4.8
LSC-30-Unc, VS	2244	0	145	2389	79.6	6.5
LSC-30-Unc, FF	2244	0	234	2478	82.6	10.4
LSC-30-DS(50), DS/PM	2244	622	w/SO_2	2866	95.5	27.7
LSC-30-DA(50), DA/PM	2244	691	w/SO_2	2935	97.8	30.8
LSC-30-DA(50), FF	2244	535	234	3013	100.4	34.3
LSC-30-DA(90), DA/PM	2244	745	w/SO_2	2989	99.6	33.2
LSC-30-DA(90), FF	2244	592	234	3070	102.3	36.8
LSC-75-Unc, Unc	4079	0	0	4079	54.4	0
LSC-75-Unc, SM	4079	0	121	4200	56.0	3.0
LSC-75-Unc, SSS	4079	0	218	4297	57.3	5.3
LSC-75-Unc, VS	4079	0	257	4336	57.8	6.3
LSC-75-Unc, FF	4079	0	613	4692	62.6	15.0
LSC-75-DS(50), DS/PM	4079	1045	w/SO_2	5124	68.3	25.6
LSC-75-DA(50), DA/PM	4079	955	w/SO_2	5034	67.1	23.4
LSC-75-DA(50), FF	4079	773	613	5465	72.9	34.0
LSC-75-DA(90), DA/PM	4079	1027	w/SO_2	5106	68.1	25.2
LSC-75-DA(90), FF	4079	856	613	5548	74.0	36.0
LSC-150-Unc, Unc	8334	0	0	8334	55.6	0
LSC-150-Unc, SM	8334	0	206	8540	56.9	2.5
LSC-150-Unc, SSS	8334	0	379	8713	58.1	4.5
LSC-150-Unc, VS	8334	0	446	8780	58.5	5.4
LSC-150-Unc, FF	8334	0	1059	9393	62.6	12.7
LSC-150-DS(50), DS/PM	8334	1637	w/SO_2	9971	66.5	19.6
LSC-150-DA(50), DA/PM	8334	1358	w/SO_2	9692	64.6	16.3
LSC-150-DA(50), FF	8334	1048	1059	10441	69.6	25.3
LSC-150-DA(90), DA/PM	8334	1432	w/SO_2	9766	65.1	17.2
LSC-150-DA(90), FF	8334	1158	1059	10551	70.3	26.6
LSC-400-Unc, Unc	18990	0	0	18990	47.5	0
LSC-400-Unc, SM	18990	0	417	19407	48.5	2.2
LSC-400-Unc, SSS	18990	0	797	19787	49.5	4.2
LSC-400-Unc, VS	18990	0	1033	20023	50.1	5.4
LSC-400-Unc, FF	18990	0	2139	21129	52.8	11.3
LSC-400-DS(50), DS/PM	18990	3333	w/SO_2	22323	55.8	17.6
LSC-400-DA(50), DA/PM	18990	2110	w/SO_2	21100	52.8	11.1
LSC-400-DA(50), FF	18990	1683	2139	22812	57.0	20.1
LSC-400-DA(90), DA/PM	18990	2222	w/SO_2	21212	53.0	11.7
LSC-400-DA(90), FF	18990	1850	2139	22979	57.4	21.0

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[a] Normalized total is total capital cost divided by boiler capacity ($1000/$10^6$ Btu/hr).

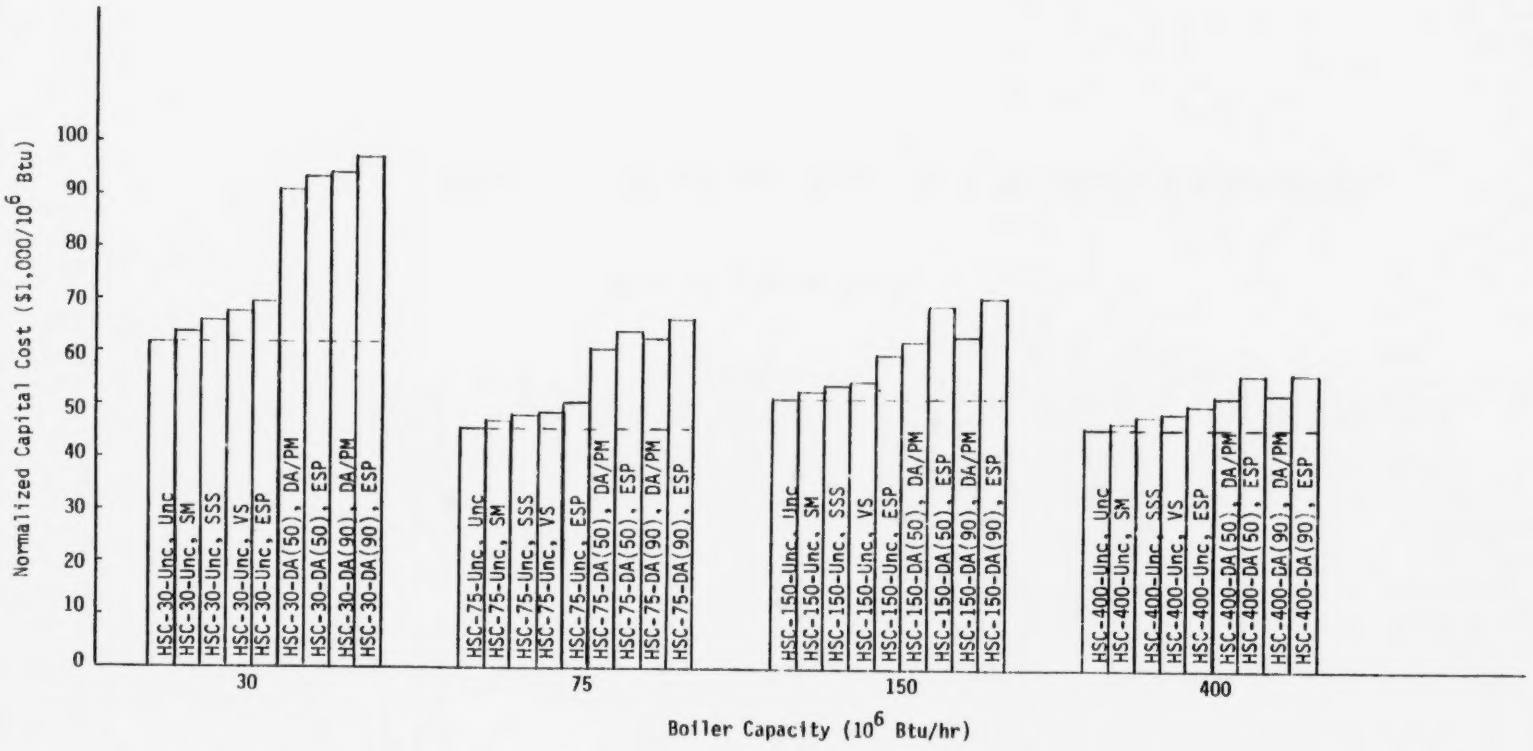

Figure 3-1. Normalized capital costs for HSC-fired model boilers.

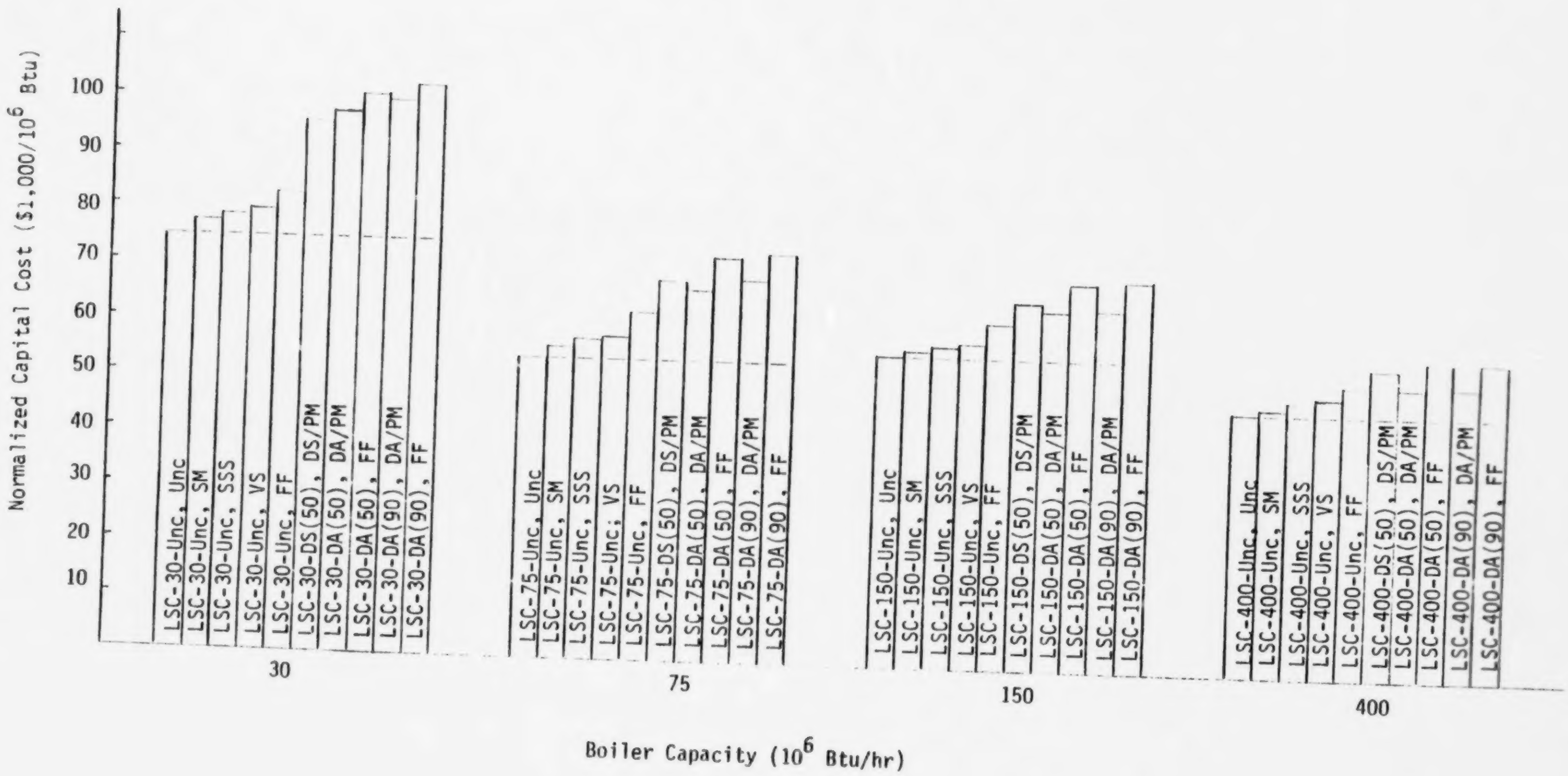

Figure 3-2. Normalized capital costs for LSC-fired model boilers.

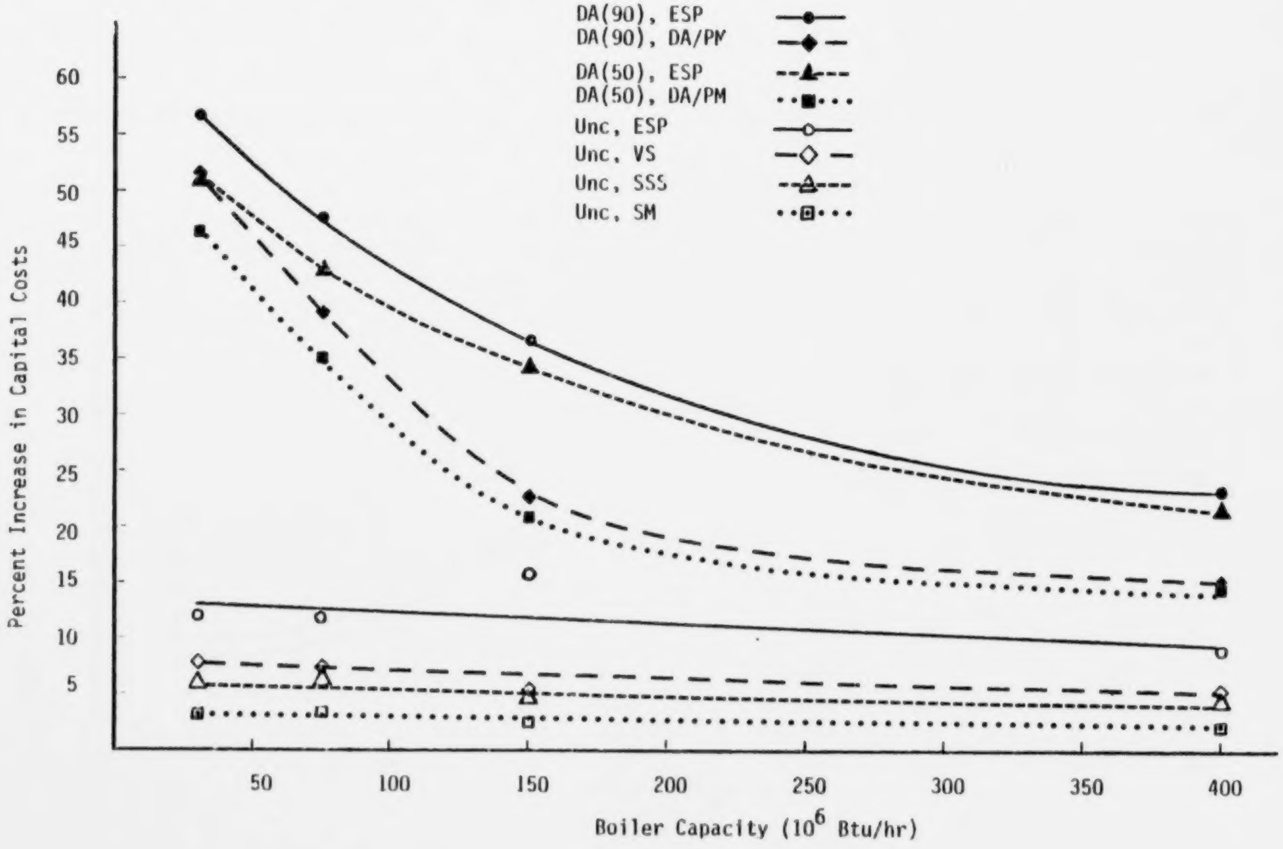

Figure 3-3. Percent increases in capital cost over uncontrolled for HSC-fired model boilers.

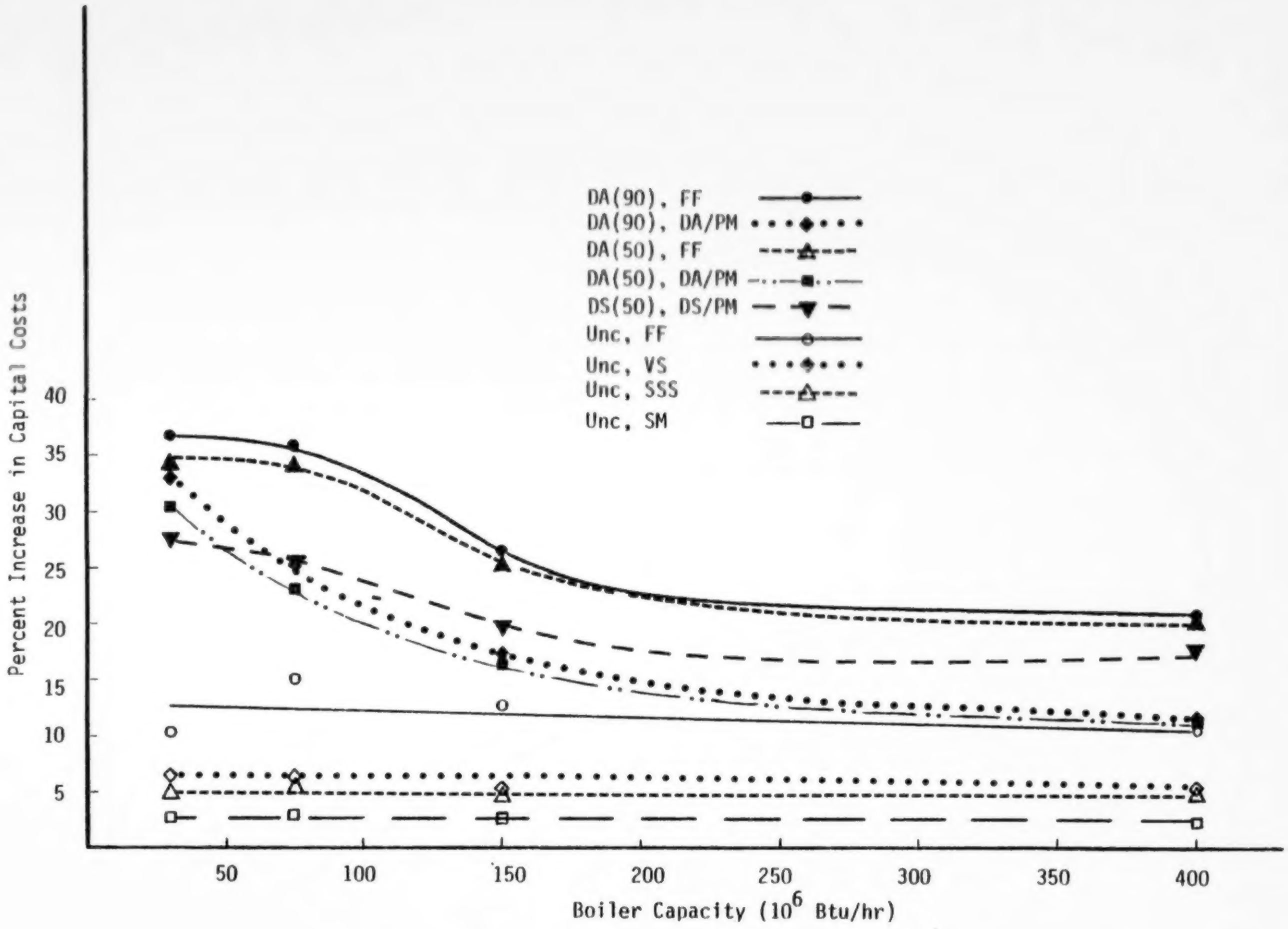

Figure 3-4. Percent increases in capital cost over uncontrolled for LSC-fired model boilers.

Costs for single mechanical collectors range from about $60,000 to $417,000 for the boiler sizes examined, and in all cases are less than 30 percent of the cost of an ESP or FF. Although more expensive than mechanical collectors, side stream separators are less than 55 percent of the cost of an ESP or FF. Venturi scrubber costs are higher than SSS costs and are typically 65 percent of an ESP or FF cost.

Based on the range of boiler sizes examined, the ESP capital costs appear to show a diseconomy of scale. However, the relatively low costs for the 30 and 75 x 10^6 Btu/hr units are more the result of two factors: (1) the inherently lower emission rate of the underfeed stoker units (0.657 lb/10^6 Btu for HSC) relative to the spreader stoker and pulverized units (2.54 - 3.81 lb/10^6 Btu for HSC) and (2) the sensitivity of ESP costs to collection efficiency. For example, the specific collection area (SCA) required to control PM emissions to 0.05 lb/10^6 Btu is about 117 $ft^2/10^3$ acfm for an underfeed stoker. But for the same control level, the SCA requirement for a spreader stoker is 189 $ft^2/10^3$ acfm. This increased plate area requirement results in a more expensive ESP for the larger boilers on a normalized cost basis.

Unlike ESPs, fabric filter costs are not sensitive to collection efficiency (i.e., for a given controlled emission rate, fabric filter costs are not a function of boiler uncontrolled PM emission rate) and thus do not exhibit capital cost diseconomies of scale. Also, fabric filter costs are not sensitive to fuel sulfur content. As noted in Appendix A (Table A-13), ESP costs are expressed as a function of coal sulfur content as well as collection efficiency. Fly ash from low sulfur coals generally is more difficult to collect than the lower resistivity ash associated with many higher sulfur coals. Thus, a larger ESP collection area may be required, with the results that an ESP is typically more expensive than a fabric filter for LSC-fired boilers.

Figures 3-1 and 3-3 show the least expensive SO_2/PM control system for HSC-fired boilers to be a double alkali FGD system used to remove PM and designed for 50 percent SO_2 removal. These systems result in cost increases from 14 to 46 percent of the uncontrolled boiler costs, with the percent increasing as boiler size decreases from 400 to 30 x 10^6 Btu/hr. The cost for the double alkali system designed for PM control and 90 percent SO_2 removal are about 10 percent higher than those for a 50 percent removal system. The higher design SO_2 removal efficiency requires larger reagent and sludge waste handling equipment, resulting in a higher capital cost.

The most expensive system for HSC-fired units is a 90 percent FGD system combined with an ESP for PM control. The cost increases over uncontrolled for this control strategy range from 23 to 57 percent of the uncontrolled boiler cost.

As seen in Figures 3-2 and 3-4 (LSC-fired model boilers), capital costs for the 50 percent SO_2 removal spray drying system are higher than those for a 90 percent SO_2 removal double alkali system at all but the smallest boiler size. This is attributable to the capital cost of the fabric filter that must be included with the spray drying system to collect fly ash and the product solids generated during SO_2 removal in the spray dryer. The most expensive system for LSC-fired units is the double alkali FGD system used in combination with a fabric filter. The capital cost of this system ranges from 21 to 37 percent of the uncontrolled boiler costs with the percentage decreasing as boiler size increases from 30 to 400 x 10^6 Btu/hr.

3.2 O&M AND TOTAL ANNUALIZED COSTS OF PM AND SO_2 CONTROL APPLIED TO COAL-FIRED BOILERS

Annual O&M costs for HSC- and LSC-fired model boilers are presented in Tables 3-3 and 3-4, respectively. The normalized annual costs provide a size independent measure of the annual O&M cost of the boiler and pollution control system. Normalized annual costs are computed by dividing the annual cost ($1000/yr) by the annual heat input to the boiler based on the capacity utilization (10^6 Btu/yr). Since a time unit is included in both numerator and denominator, the final unit for normalized annual cost is $/$10^6$ Btu.

Total annualized costs, which include annual capital charges, are presented in a similar manner in Tables 3-5 and 3-6. Figures 3-5 and 3-6 provide a bar-chart representation of the normalized total annualized costs. On an annualized basis, the uncontrolled boilers show a smooth step down in

TABLE 3-3. ANNUAL O&M COSTS FOR HSC-FIRED MODEL BOILERS

Model Boiler	Annual O&M Costs ($1000/yr)				Normalized Total[a]	% Increase Over Uncontrolled
	Uncontrolled Boiler	SO_2 Control	PM Control	Total		
HSC-30-Unc, Unc	649	0	0	649	4.12	0
HSC-30-Unc, SM	649	0	18.3	667	4.23	2.8
HSC-30-Unc, SSS	649	0	27.0	676	4.29	4.2
HSC-30-Unc, VS	649	0	33.3	682	4.32	5.1
HSC-30-Unc, ESP	649	0	32.3	681	4.32	4.9
HSC-30-DA(50), DA/PM	649	265	w/SO_2	914	5.80	40.8
HSC-30-DA(50), ESP	649	253	32.3	934	5.92	43.9
HSC-30-DA(90), DA/PM	649	289	w/SO_2	938	5.95	44.5
HSC-30-DA(90), ESP	649	277	32.3	958	6.08	47.6
HSC-75-Unc, Unc	1382	0	0	1382	3.51	0
HSC-75-Unc, SM	1382	0	25.2	1407	3.57	1.8
HSC-75-Unc, SSS	1382	0	38.6	1421	3.60	2.8
HSC-75-Unc, VS	1382	0	55.9	1438	3.65	4.1
HSC-75-Unc, ESP	1382	0	41.3	1423	3.61	3.0
HSC-75-DA(50), DA/PM	1382	327	w/SO_2	1709	4.34	23.7
HSC-75-DA(50), ESP	1382	310	41.3	1733	4.40	25.4
HSC-75-DA(90), DA/PM	1382	379	w/SO_2	1761	4.47	27.4
HSC-75-DA(90), ESP	1382	365	41.3	1788	4.54	29.4
HSC-150-Unc, Unc	2204	0	0	2204	2.80	0
HSC-150-Unc, SM	2204	0	47.2	2251	2.86	2.1
HSC-150-Unc, SSS	2204	0	69.5	2274	2.88	3.2
HSC-150-Unc, VS	2204	0	104	2308	2.93	4.7
HSC-150-Unc, ESP	2204	0	73.7	2278	2.89	3.4
HSC-150-DA(50), DA/PM	2204	434	w/SO_2	2638	3.35	19.7
HSC-150-DA(50), ESP	2204	394	73.7	2672	3.39	21.2
HSC-150-DA(90), DA/PM	2204	533	w/SO_2	2737	3.47	24.2
HSC-150-DA(90), ESP	2204	496	73.7	2774	3.52	25.9
HSC-400-Unc, Unc	5603	0	0	5603	2.67	0
HSC-400-Unc, SM	5603	0	120	5723	2.72	2.1
HSC-400-Unc, SSS	5603	0	177	5780	2.75	3.2
HSC-400-Unc, VS	5603	0	262	5865	2.79	4.7
HSC-400-Unc, ESP	5603	0	177	5780	2.75	3.2
HSC-400-DA(50), DA/PM	5603	757	w/SO_2	6360	3.03	13.5
HSC-400-DA(50), ESP	5603	644	177	6424	3.06	14.7
HSC-400-DA(90), DA/PM	5603	1008	w/SO_2	6611	3.14	18.0
HSC-400-DA(90), ESP	5603	899	177	6679	3.18	19.2

[a] Normalized total is total O&M cost divided by annual heat input ($/$10^6$ Btu).

TABLE 3-4. ANNUAL O&M COSTS FOR LSC-FIRED MODEL BOILERS

Model Boiler	Annual O&M Costs ($1000/yr)				Normalized Total[a]	% Increase Over Uncontrolled
	Uncontrolled Boiler	SO_2 Control	PM Control	Total		
LSC-30-Unc, Unc	758	0	0	758	4.81	0
LSC-30-Unc, SM	758	0	18.5	777	4.93	2.5
LSC-30-Unc, SSS	758	0	27.3	785	4.98	3.6
LSC-30-Unc, VS	758	0	33.5	792	5.02	4.5
LSC-30-Unc, FF	758	0	39.9	798	5.06	5.3
LSC-30-DS(50), DS/PM	758	238	w/SO_2	996	6.32	31.4
LSC-30-DA(50), DA/PM	758	238	w/SO_2	996	6.32	31.4
LSC-30-DA(50), FF	758	224	39.9	1022	6.48	34.8
LSC-30-DA(90), DA/PM	758	245	w/SO_2	1003	6.36	32.3
LSC-30-DA(90), FF	758	232	39.9	1030	6.53	35.9
LSC-75-Unc, Unc	1642	0	0	1642	4.17	0
LSC-75-Unc, SM	1642	0	25.8	1668	4.23	1.6
LSC-75-Unc, SSS	1642	0	39.3	1681	4.26	2.4
LSC-75-Unc, VS	1642	0	56.3	1698	4.31	3.4
LSC-75-Unc, FF	1642	0	60.6	1703	4.32	3.7
LSC-75-DS(50), DS/PM	1642	264	w/SO_2	1906	4.84	16.1
LSC-75-DA(50), DA/PM	1642	271	w/SO_2	1913	4.85	16.5
LSC-75-DA(50), FF	1642	251	60.6	1954	4.96	19.0
LSC-75-DA(90), DA/PM	1642	284	w/SO_2	1926	4.89	17.3
LSC-75-DA(90), FF	1642	266	60.6	1969	4.99	19.9
LSC-150-Unc, Unc	2671	0	0	2671	3.39	0
LSC-150-Unc, SM	2671	0	50.9	2722	3.45	1.9
LSC-150-Unc, SSS	2671	0	73.5	2745	3.48	2.8
LSC-150-Unc, VS	2671	0	107	2778	3.52	4.0
LSC-150-Unc, FF	2671	0	109	2780	3.53	4.1
LSC-150-DS(50), DS/PM	2671	317	w/SO_2	2988	3.79	11.9
LSC-150-DA(50), DA/PM	2671	340	w/SO_2	3011	3.82	12.7
LSC-150-DA(50), FF	2671	288	109	3068	3.89	14.9
LSC-150-DA(90), DA/PM	2671	362	w/SO_2	3033	3.85	13.6
LSC-150-DA(90), FF	2671	313	109	3093	3.92	15.8
LSC-400-Unc, Unc	6856	0	0	6856	3.26	0
LSC-400-Unc, SM	6856	0	98.5	6955	3.31	1.4
LSC-400-Unc, SSS	6856	0	156	7012	3.34	2.3
LSC-400-Unc, VS	6856	0	240	7096	3.38	3.5
LSC-400-Unc, FF	6856	0	239	7095	3.37	3.5
LSC-400-DS(50), DS/PM	6856	451	w/SO_2	7307	3.47	6.6
LSC-400-DA(50), DA/PM	6856	484	w/SO_2	7340	3.49	7.1
LSC-400-DA(50), FF	6856	389	239	7484	3.56	9.2
LSC-400-DA(90), DA/PM	6856	538	w/SO_2	7394	3.52	7.8
LSC-400-DA(90), FF	6856	446	239	7541	3.59	10.0

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[a] Normalized total is total O&M cost divided by annual heat input ($/$10^6$ Btu).

TABLE 3-5. TOTAL ANNUALIZED COSTS FOR HSC-FIRED MODEL BOILERS

Model Boiler	Annualized Costs ($1000/yr)				Normalized Total[a]	% Increase Over Uncontrolled
	Uncontrolled Boiler	SO_2 Control	PM Control	Total		
HSC-30-Unc, Unc	961	0	0	961	6.09	0
HSC-30-Unc, SM	961	0	28.4	989	6.27	2.9
HSC-30-Unc, SSS	961	0	44.7	1006	6.38	4.7
HSC-30-Unc, VS	961	0	57.4	1018	6.46	5.9
HSC-30-Unc, ESP	961	0	70.5	1032	6.54	7.4
HSC-30-DA(50), DA/PM	961	410	w/SO_2	1371	8.69	42.7
HSC-30-DA(50), ESP	961	373	70.5	1405	8.91	46.2
HSC-30-DA(90), DA/PM	961	450	w/SO_2	1411	8.95	46.8
HSC-30-DA(90), ESP	961	416	70.5	1448	9.18	50.7
HSC-75-Unc, Unc	1948	0	0	1948	4.94	0
HSC-75-Unc, SM	1948	0	45.2	1993	5.05	2.3
HSC-75-Unc, SSS	1948	0	74.7	2023	5.13	3.8
HSC-75-Unc, VS	1948	0	98.3	2046	5.19	5.0
HSC-75-Unc, ESP	1948	0	111	2059	5.22	5.7
HSC-75-DA(50), DA/PM	1948	525	w/SO_2	2473	6.27	27.0
HSC-75-DA(50), ESP	1948	485	111	2544	6.45	30.6
HSC-75-DA(90), DA/PM	1948	600	w/SO_2	2548	6.46	30.8
HSC-75-DA(90), ESP	1948	566	111	2625	6.66	34.8
HSC-150-Unc, Unc	3511	0	0	3511	4.45	0
HSC-150-Unc, SM	3511	0	80.9	3592	4.56	2.3
HSC-150-Unc, SSS	3511	0	132	3643	4.62	3.8
HSC-150-Unc, VS	3511	0	177	3688	4.68	5.0
HSC-150-Unc, ESP	3511	0	282	3793	4.81	8.0
HSC-150-DA(50), DA/PM	3511	702	w/SO_2	4213	5.34	20.0
HSC-150-DA(50), ESP	3511	630	282	4423	5.61	26.0
HSC-150-DA(90), DA/PM	3511	828	w/SO_2	4339	5.50	23.6
HSC-150-DA(90), ESP	3511	768	282	4561	5.79	29.9
HSC-400-Unc, Unc	8699	0	0	8699	4.14	0
HSC-400-Unc, SM	8699	0	189	8888	4.23	2.2
HSC-400-Unc, SSS	8699	0	309	9008	4.28	3.6
HSC-400-Unc, VS	8699	0	432	9131	4.34	5.0
HSC-400-Unc, ESP	8699	0	466	9165	4.36	5.4
HSC-400-DA(50), DA/PM	8699	1177	w/SO_2	9876	4.70	13.5
HSC-400-DA(50), ESP	8699	1016	466	10181	4.84	17.0
HSC-400-DA(90), DA/PM	8699	1466	w/SO_2	10165	4.83	16.9
HSC-400-DA(90), ESP	8699	1327	466	10492	4.99	20.6

[a] Normalized total is total annual cost divided by annual heat input ($\$/10^6$ Btu).

TABLE 3-6. TOTAL ANNUALIZED COSTS FOR LSC-FIRED MODEL BOILERS

Model Boiler	Annualized Costs ($1000/yr)				Normalized Total[a]	% Increase Over Uncontrolled
	Uncontrolled Boiler	SO_2 Control	PM Control	Total		
LSC-30-Unc, Unc	1136	0	0	1136	7.20	0
LSC-30-Unc, SM	1136	0	28.9	1165	7.39	2.6
LSC-30-Unc, SSS	1136	0	45.3	1181	7.49	4.0
LSC-30-Unc, VS	1136	0	57.9	1194	7.57	5.1
LSC-30-Unc, FF	1136	0	79.5	1216	7.71	7.0
LSC-30-DS(50), DS/PM	1136	342	w/SO_2	1478	9.37	30.1
LSC-30-DA(50), DA/PM	1136	353	w/SO_2	1489	9.44	31.1
LSC-30-DA(50), FF	1136	313	79.5	1529	9.70	34.6
LSC-30-DA(90), DA/PM	1136	370	w/SO_2	1506	9.55	32.6
LSC-30-DA(90), FF	1136	330	79.5	1546	9.80	36.1
LSC-75-Unc, Unc	2326	0	0	2326	5.90	0
LSC-75-Unc, SM	2326	0	46.2	2372	6.02	2.0
LSC-75-Unc, SSS	2326	0	76.2	2402	6.09	3.3
LSC-75-Unc, VS	2326	0	99.5	2426	6.15	4.3
LSC-75-Unc, FF	2326	0	165	2491	6.32	7.1
LSC-75-DS(50), DS/PM	2326	440	w/SO_2	2766	7.02	18.9
LSC-75-DA(50), DA/PM	2326	431	w/SO_2	2757	6.99	18.5
LSC-75-DA(50), FF	2326	381	165	2872	7.29	23.5
LSC-75-DA(90), DA/PM	2326	457	w/SO_2	2783	7.06	19.6
LSC-75-DA(90), FF	2326	409	165	2900	7.36	24.7
LSC-150-Unc, Unc	4078	0	0	4078	5.17	0
LSC-150-Unc, SM	4078	0	85.4	4163	5.28	2.1
LSC-150-Unc, SSS	4078	0	137	4215	5.35	3.4
LSC-150-Unc, VS	4078	0	182	4260	5.40	4.5
LSC-150-Unc, FF	4078	0	289	4367	5.54	7.1
LSC-150-DS(50), DS/PM	4078	594	w/SO_2	4672	5.93	14.6
LSC-150-DA(50), DA/PM	4078	568	w/SO_2	4646	5.89	13.9
LSC-150-DA(50), FF	4078	464	289	4831	6.13	18.5
LSC-150-DA(90), DA/PM	4078	603	w/SO_2	4681	5.94	14.8
LSC-150-DA(90), FF	4078	507	289	4875	6.78	19.5
LSC-400-Unc, Unc	10056	0	0	10056	4.78	0
LSC-400-Unc, SM	10056	0	169	10225	4.86	1.7
LSC-400-Unc, SSS	10056	0	290	10346	4.92	2.9
LSC-400-Unc, VS	10056	0	413	10469	4.98	4.1
LSC-400-Unc, FF	10056	0	602	10658	5.07	6.0
LSC-400-DS(50), DS/PM	10056	1016	w/SO_2	11072	5.27	10.1
LSC-400-DA(50), DA/PM	10056	839	w/SO_2	10895	5.18	8.3
LSC-400-DA(50), FF	10056	672	602	11330	5.39	12.7
LSC-400-DA(90), DA/PM	10056	911	w/SO_2	10967	5.22	9.1
LSC-400-DA(90), FF	10056	756	602	11414	5.43	13.5

[a] Normalized total is total annual cost divided by annual heat input ($/$10^6$ Btu).

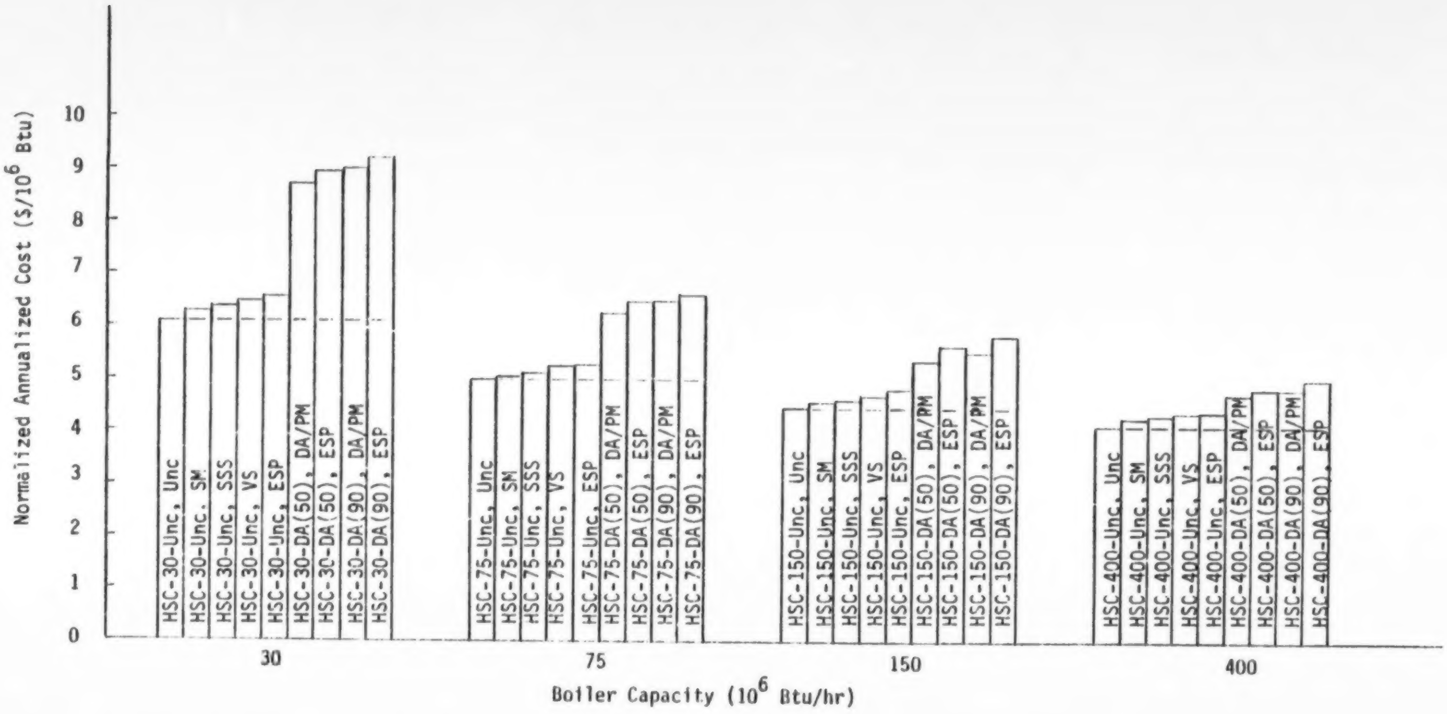


Figure 3-5. Normalized annualized costs for HSC-fired model boilers.

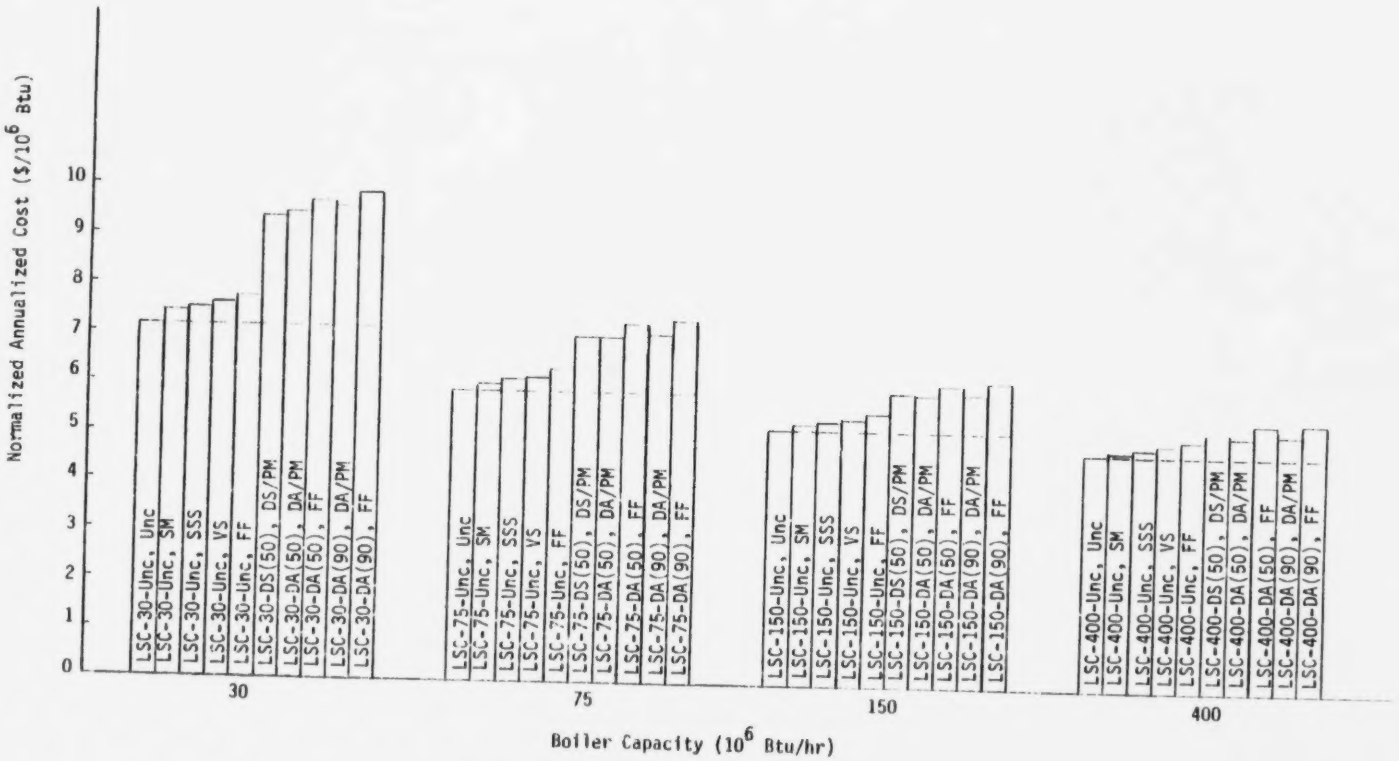


Figure 3-6. Normalized annualized costs for LSC-fired model boilers.

normalized costs with boiler size indicating economies of scale with larger boilers.

Finally, Figures 3-7 and 3-8 provide plots of percent increases in annualized costs over uncontrolled as a function of boiler size. As was noted in capital costs, the LSC-fired model boilers show lower percent increases for all control strategies. In annual costs, the higher cost of LSC compared to HSC is strongly evident, resulting in much higher costs for the uncontrolled cases. This results in lower percent increases in costs for controlled LSC-fired model boilers for each control scheme.

Mechanical collectors and side stream separators are the least expensive control devices on an annualized cost basis as well as a capital cost basis. The ESP costs again exhibit a slight apparent diseconomy of scale due to the difference in boiler uncontrolled PM emission rates. This is primarily due to the capital cost difference being carried over in the capital charges component of annualized costs.

The application of an FGD system to an HSC-fired boiler results in at least a 13 percent increase in annualized costs over the uncontrolled boiler. Unlike the costs for PM control technologies, however, FGD costs are a fairly strong function of size below about 250 x 10^6 Btu/hr. For example, an FGD system used to remove PM and designed for 50 percent SO_2 removal for HSC-firing results in about a 20 percent increase in steam costs for a 150 x 10^6 Btu/hr unit. But the same system applied to a 30 x 10^6 Btu/hr unit results in a 43 percent increase over uncontrolled. The largest percent increases due to FGD costs are observed for small boilers.

The difference in the percent increase in annualized costs over uncontrolled between 50 and 90 percent SO_2 removal FGD systems is about 3 to 4 percent for all HSC-fired boiler sizes. This translates into annual savings of from $40,000/yr for a 30 x 10^6 Btu/hr unit to about $289,000/yr for a 400 x 10^6 Btu/hr unit. The savings result from (1) reduced capital charges associated with the smaller reagent and sludge handling facilities for the 50 percent system, (2) reduced sludge volumes to be disposed of, and (3) reduced reagent consumption.

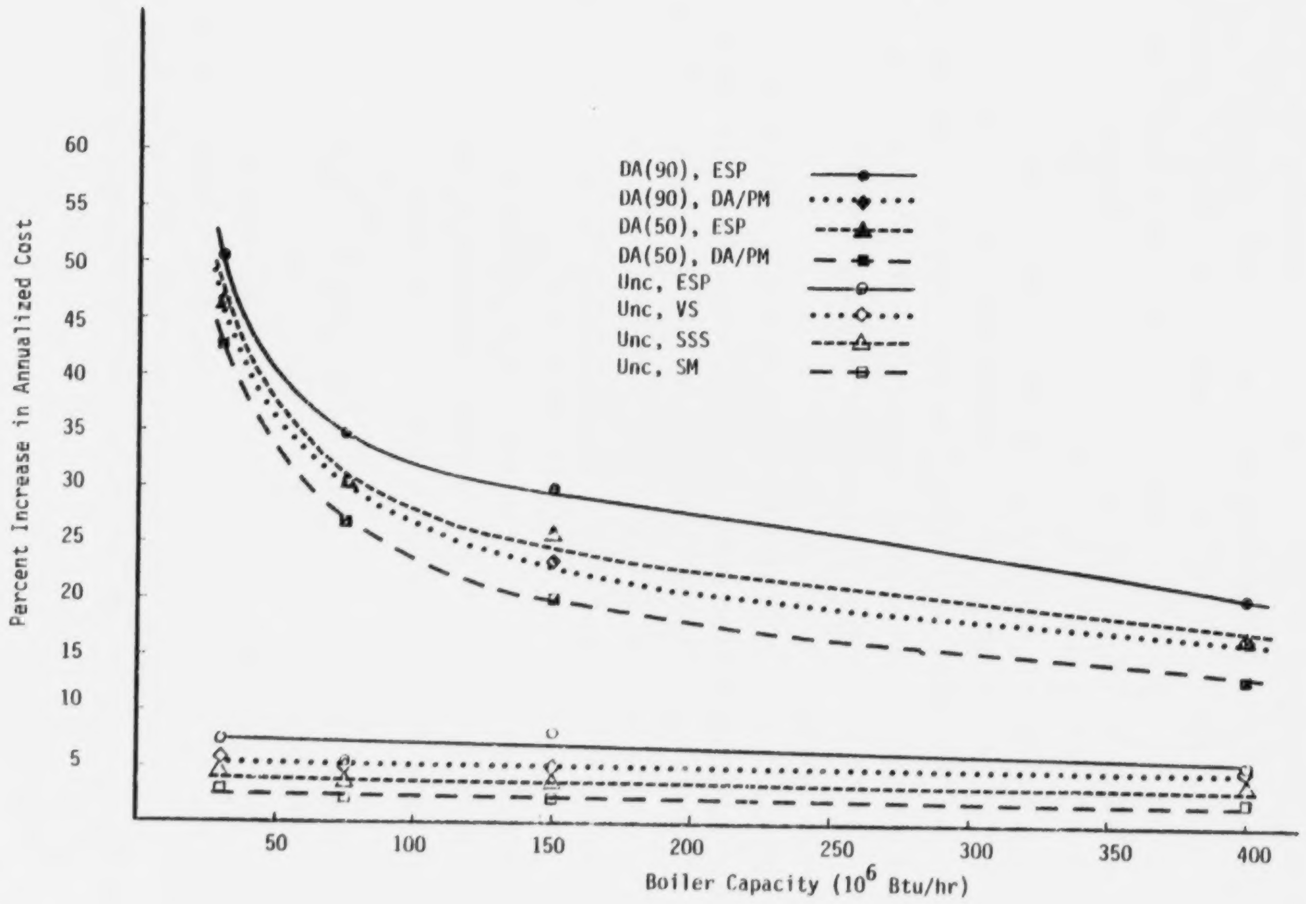


Figure 3-7. Percent increases in annualized cost over uncontrolled for HSC-fired model boilers.

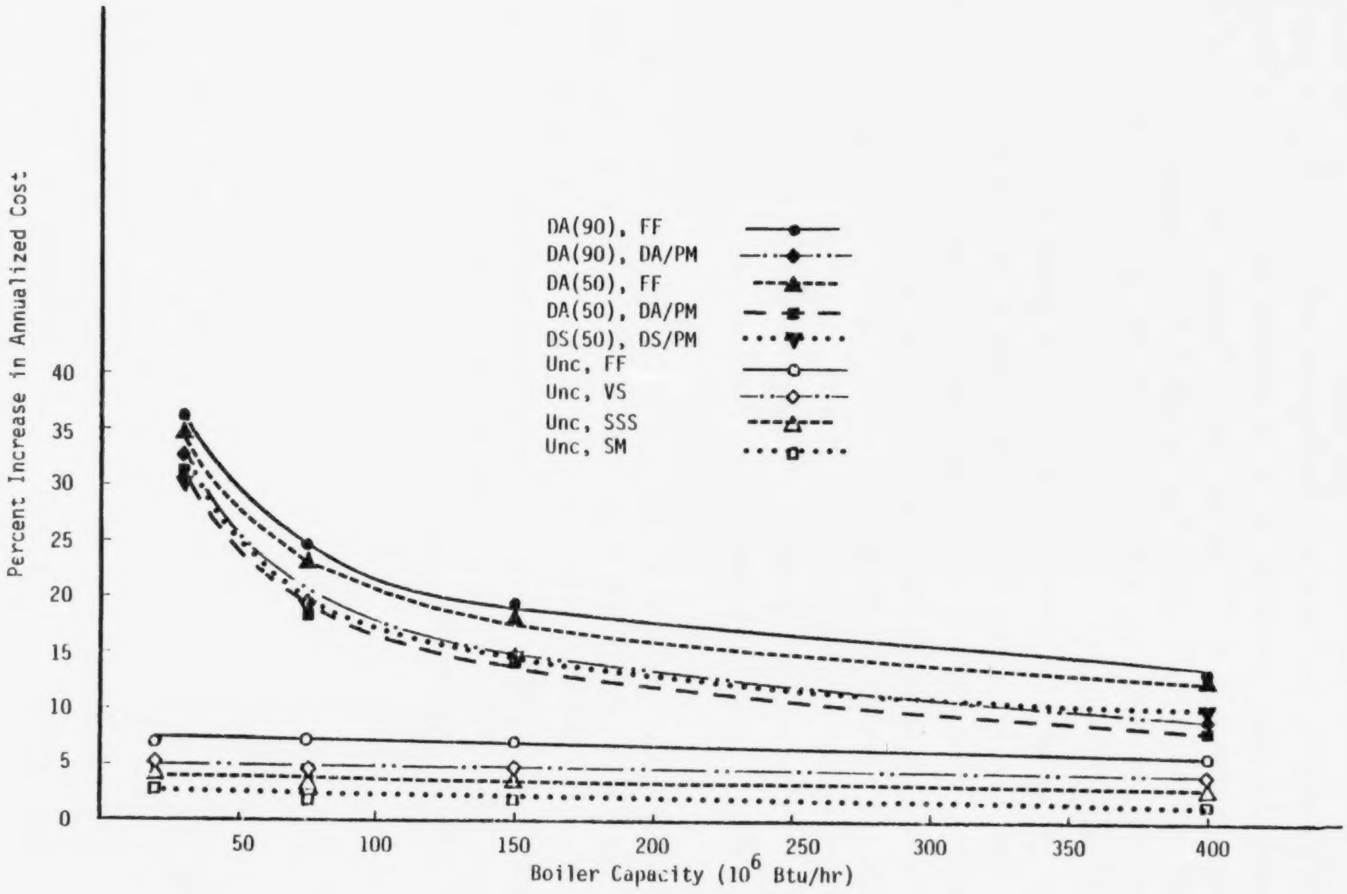


Figure 3-8. Percent increases in annualized cost over uncontrolled for LSC-fired model boilers.

Figure 3-7 indicates that a 90 percent removal FGD system used in combination with an ESP on a HSC-fired model boiler results in annualized costs increases over uncontrolled of 21 percent for a 400 x 10^6 Btu/hr unit to 51 percent for a 30 x 10^6 Btu/hr unit. Percent cost increases for 400 x 10^6 Btu/hr boilers controlled by FGD/ESP are approximately equivalent to increases attributed to combined SO_2/PM FGD systems at the 150 x 10^6 Btu/hr capacity.

For the range of LSC-fired model boilers examined, the annualized costs of applying a double alkali FGD system to remove both PM and SO_2 (90 percent SO_2 removal) are roughly equal to the costs of a lime spray drying/fabric filter system designed for 50 percent SO_2 removal. As discussed earlier, the spray drying system includes a fabric filter and is therefore more expensive than the double alkali scrubber on a capital costs basis. However, this difference in capital charges is somewhat balanced by the reduced waste disposal and reagent costs associated with the spray drying system.

A double alkali system (90 percent SO_2 removal) used in combination with a fabric filter results in the largest percentage increase over uncontrolled for the SO_2/PM systems applied to LSC-fired boilers. Use of this control strategy results in increases over uncontrolled of from 13 percent for a 400 x 10^6 Btu/hr pulverized coal boiler to 36 percent for a 30 x 10^6 Btu/hr underfeed stoker.

4.0 COSTS OF PM AND SO_2 CONTROL FOR RESIDUAL OIL-FIRED BOILERS

This chapter presents the results of the model boiler cost analysis of various PM and SO_2 control technologies applied to residual oil-fired boilers. Capital costs are presented in the first portion of the chapter, while annual O&M and annualized costs are discussed in the second portion. Two sizes of residual oil-fired model boilers are evaluated: 30 and 150 x 10^6 Btu/hr. In addition to the uncontrolled case, costs are presented for (1) the use of an ESP, (2) the use of a double alkali FGD system for PM and SO_2 removal (50 and 90 percent), and (3) the use of a double alkali system (50 and 90 percent SO_2 removal) and an ESP. For the small 30 x 10^6 Btu/hr size the costs for a sodium throwaway system (50 and 90 percent SO_2 removal) used alone or with an ESP are also presented. Use of sodium throwaway systems is especially suited to oil-field steam generators used for thermal enhanced oil recovery. In these applications, the waste liquor can generally be reused, thus eliminating expensive treatment processes that would otherwise make the sodium throwaway system uneconomical in comparison to a double alkali system.

4.1 CAPITAL COSTS OF PM AND SO_2 CONTROLS APPLIED TO RESIDUAL OIL-FIRED BOILERS

Table 4-1 presents capital costs for the residual oil-fired model boilers defined in Chapter 2. Normalized costs, shown in the sixth column of the table, are a measure of the total capital investment ($1,000) per unit of installed heat input capacity (10^6 Btu/hr). The normalized capital costs are graphically depicted in Figure 4-1.

The most expensive control system is the double alkali FGD system used with an ESP, followed by the use of a double alkali system used to remove both SO_2 and PM. The capital costs of the sodium throwaway system applied to the 30 x 10^6 Btu/hr unit are substantially less than for the double alkali systems since no solids handling equipment is required for the sodium throwaway system.

TABLE 4-1. CAPITAL COSTS FOR RESIDUAL OIL-FIRED MODEL BOILERS

	Capital Costs ($1000)					
	Uncontrolled Boiler	SO_2 Control	PM Control	Total	Normalized Total[a]	% Increase Over Uncontrolled
RES-30-Unc, Unc	577	0	0	577	19.23	0
RES-30-Unc, ESP	577	0	396	973	32.43	68.6
RES-30-NATH(50), NATH/PM	577	361	w/SO_2	938	31.27	62.6
RES-30-NATH(50), ESP	577	361	396	1334	44.47	131.2
RES-30-NATH(90), NATH/PM	577	391	w/SO_2	968	32.27	67.8
RES-30-NATH(90), ESP	577	391	396	1364	45.47	136.4
RES-30-DA(90), DA/PM	577	832	w/SO_2	1409	46.97	144.2
RES-30-DA(90), ESP	577	694	396	1667	55.57	188.9
RES-150-Unc, Unc	2126	0	0	2126	141.17	0
RES-150-Unc, ESP	2126	0	1055	3181	21.21	49.6
RES-150-DA(50), DA/PM	2126	1338	w/SO_2	3464	23.09	62.9
RES-150-DA(50), ESP	2126	1174	1055	4355	29.03	104.8
RES-150-DA(90), DA/PM	2126	1475	w/SO_2	3601	24.01	69.4
RES-150-DA(90), ESP	2126	1338	1055	4519	30.13	112.6

[a] $1000/$10^6$ Btu/hr.

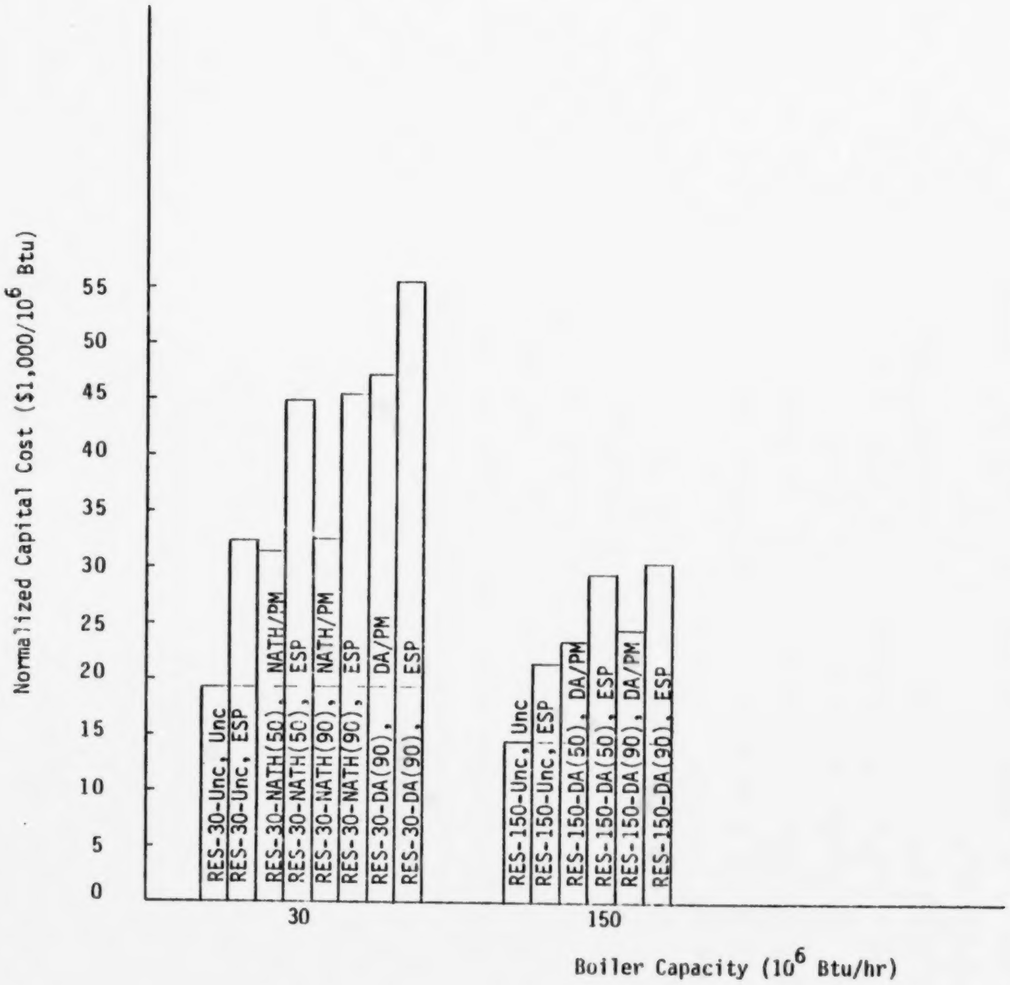


Figure 4-1. Normalized capital costs for residual oil-fired model boilers.

Capital cost increases over uncontrolled for the double alkali/ESP system range from 105 percent for 50 percent SO_2 control on a 150 x 10^6 Btu/hr unit to 189 percent for 90 percent SO_2 control on a 30 x 10^6 Btu/hr model. These large percent increases over uncontrolled are primarily due to the low capital cost of the boilers. Capital costs for an ESP are 50 percent over uncontrolled for the 150 x 10^6 Btu/hr unit and 69 percent for the 30 x 10^6 Btu/hr boiler.

4.2 O&M AND TOTAL ANNUALIZED COSTS OF PM AND SO_2 CONTROL FOR OIL-FIRED BOILERS

Annual O&M costs for the residual oil-fired model boilers are presented in Table 4-2 while total annualized costs (including capital charge components) are shown in Table 4-3. The normalized annualized costs are presented graphically in Figure 4-2. This figure gives an indication of the economies of scale associated with the annualized costs of boilers and control systems.

The annualized cost impact of control over uncontrolled is less for the 150 x 10^6 Btu/hr boilers than the 30 x 10^6 Btu/hr boiler. This occurs because of the apparent economies of scale with the larger 150 x 10^6 Btu/hr boiler and the associated control equipment. The double alkali/ESP system (the most expensive system on an annualized as well as a capital cost basis) results in a 20 and 47 percent increase over uncontrolled. The use of an ESP without SO_2 control results in a 5 and 10 percent increase in costs for the two boiler sizes evaluated.

TABLE 4-2. ANNUAL O&M COSTS FOR RESIDUAL OIL-FIRED MODEL BOILERS

	Annual O&M Costs ($1000/yr)					
	Uncontrolled Boiler	SO_2 Control	PM Control	Total	Normalized Total[a]	% Increase Over Uncontrolled
RES-30-Unc, Unc	894	0	0	894	6.19	0
RES-30-Unc, ESP	894	0	28.4	922	6.38	3.1
RES-30-NATH(50), NATH/PM	894	237	w/SO_2	1131	7.82	26.5
RES-30-NATH(50), ESP	894	237	28.4	1159	8.02	29.6
RES-30-NATH(90), NATH/PM	894	259	w/SO_2	1153	7.98	29.0
RES-30-NATH(90), ESP	894	259	28.4	1181	8.17	32.1
RES-30-DA(90), DA/PM	894	259	w/SO_2	1153	7.98	29.0
RES-30-DA(90), ESP	894	248	28.4	1170	8.09	30.9
RES-150-Unc, Unc	3863	0	0	3863	5.35	0
RES-150-Unc, ESP	3863	0	51.8	3915	5.42	1.3
RES-150-DA(50), DA/PM	3863	341	w/SO_2	4204	5.82	8.8
RES-150-DA(50), ESP	3863	322	51.8	4237	5.86	9.7
RES-150-DA(90), DA/PM	3863	392	w/SO_2	4255	5.89	10.1
RES-150-DA(90), ESP	3863	374	51.8	4289	5.93	11.0

[a] $/$10^6$ Btu.

TABLE 4-3. TOTAL ANNUALIZED COSTS FOR RESIDUAL OIL-FIRED MODEL BOILERS

	Annualized Costs ($1000/yr)					
	Uncontrolled Boiler	SO_2 Control	PM Control	Total	Normalized Total[a]	% Increase Over Uncontrolled
RES-30-Unc, Unc	986	0	0	986	6.82	0
RES-30-Unc, ESP	986	0	95.9	1082	7.49	9.7
RES-30-NATH(50), NATH/PM	986	296	w/SO_2	1282	8.87	30.0
RES-30-NATH(50), ESP	986	296	95.9	1378	9.53	39.8
RES-30-NATH(90), NATH/PM	986	322	w/SO_2	1308	9.05	32.7
RES-30-NATH(90), ESP	986	322	95.9	1404	9.71	42.4
RES-30-DA(90), DA/PM	986	399	w/SO_2	1385	9.58	40.5
RES-30-DA(90), ESP	986	364	95.9	1446	10.00	46.7
RES-150-Unc, Unc	4202	0	0	4202	5.81	0
RES-150-Unc, ESP	4202	0	232	4434	6.14	5.5
RES-150-DA(50), DA/PM	4202	566	w/SO_2	4768	6.60	13.5
RES-150-DA(50), ESP	4202	519	232	4953	6.85	17.9
RES-150-DA(90), DA/PM	4202	639	w/SO_2	4841	6.70	15.2
RES-150-DA(90), ESP	4202	598	232	5032	6.96	19.8

[a] $\$/10^6$ Btu.

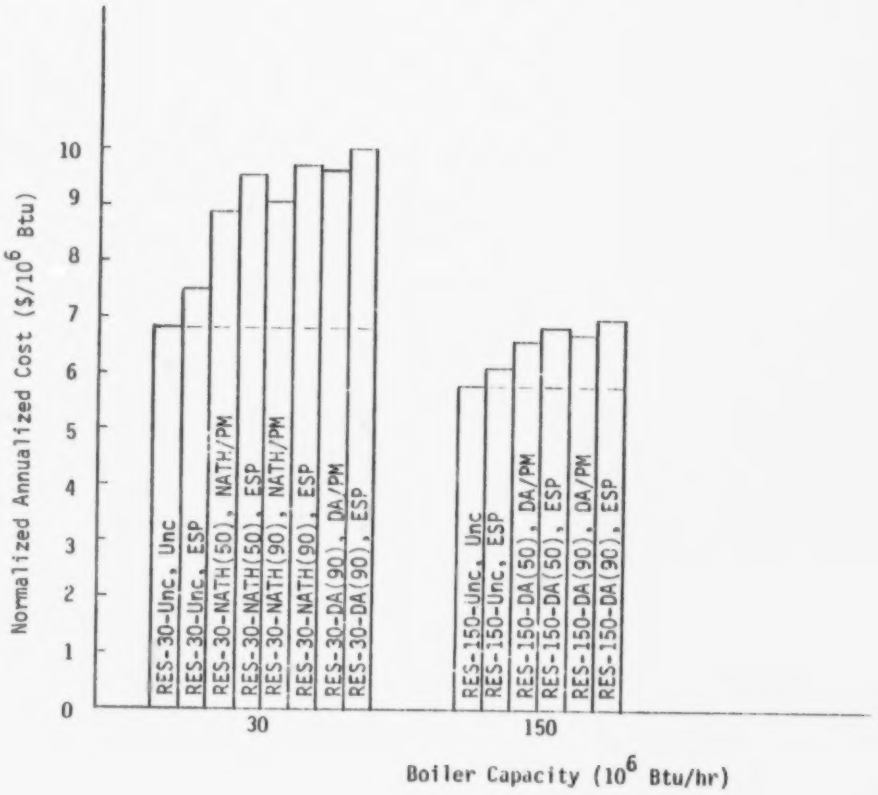


Figure 4-2. Normalized annualized costs for residual oil-fired model boilers.

5.0 NO_x CONTROL COSTS

Chapter five presents the methodology and bases for calculating the cost of NO_x control on industrial boilers firing coal, residual oil, distillate oil, and natural gas. Four types of NO_x control (combustion modifications) are analyzed; low excess air (LEA), staged combustion air (SCA), flue gas recirculation (FGR), and reduced air preheat (RAP).

Cost algorithms are used in this chapter to calculate the cost of NO_x control. Section 5.1 presents the boiler cases that will be analyzed. In addition, the emission reduction achievable with these controls will be presented. Section 5.2 discusses the sources and bases of the NO_x control cost algorithms. Finally, Section 5.3 presents the calculated capital, annual operating and maintenance (O&M), and annualized costs for the four types of NO_x controls applied to the boiler cases presented in Section 5.1.

5.1 SELECTION OF NO_x CONTROL CASES

Table 5-1 presents the control cases selected for the NO_x control cost analysis. The boilers selected represent the range of boiler sizes expected to be built for each fuel type. Table 5-1 also presents the NO_x controls that are applicable to each boiler type and the achievable NO_x emission reduction.

5.2 COST CALCULATION APPROACH

The costs presented in this chapter are the incremental costs for NO_x control and are presented in mid-1978 dollars. The costs for each NO_x combustion modification are calculated and presented in terms of:

- Capital costs of the control
- Annual operating and maintenance (O&M) costs due to the application of the control
- Annualized costs (annual O&M costs plus capital related charges)

TABLE 5-1. NO_x CONTROL CASES AND EMISSION LEVELS[1,2,3]

Control Case	Emissions lb/10^6 Btu Uncontrolled[b]	Emissions lb/10^6 Btu Controlled	Removal Efficiency (Percent)
Coal[a]			
UNDR-30-LEA	0.40	0.32	20
UNDR-75-LEA	0.40	0.32	20
SPRD-150-LEA	0.64	0.50	22
SPRD-250-LEA	0.64	0.50	22
PLVR-150-LEA	0.90	0.76	16
PLVR-150-SCA	0.90	0.58	36
PLVR-250-LEA	0.90	0.76	16
PLVR-250-SCA	0.90	0.58	36
PLVR-400-LEA	0.90	0.76	16
PLVR-400-SCA	0.90	0.58	36
0.2 Weight % Nitrogen Residual Oil			
RES-30-LEA	0.29	0.26	10
RES-150-LEA	0.29	0.26	10
RES-250-LEA	0.29	0.26	10
0.4 Weight % Nitrogen Residual Oil			
RES-30-LEA	0.43	0.40	7
RES-30-SCA	0.43	0.24	42
RES-150-LEA	0.43	0.40	7
RES-150-SCA	0.43	0.24	42
RES-250-LEA	0.43	0.40	7
RES-250-SCA	0.43	0.24	42

TABLE 5-1. (Continued)

Control Case	Emissions lb/10^6 Btu		Removal Efficiency (Percent)
	Uncontrolled[b]	Controlled	
Distillate Oil			
DIS-30-LEA	0.25	0.16	36
DIS-30-FGR	0.25	0.19	24
DIS-30-RAP[c]	0.25	0.19	24
DIS-150-LEA	0.25	0.16	36
DIS-150-FGR	0.25	0.19	24
DIS-150-RAP[c]	0.25	0.19	24
DIS-250-LEA	0.25	0.16	36
DIS-250-FGR	0.25	0.19	24
DIS-250-RAP[c]	0.25	0.19	24
Natural Gas			
NG-30-LEA	0.26	0.22	15
NG-30-FGR	0.26	0.18	31
NG-30-RAP[c]	0.26	0.18	31
NG-150-LEA	0.26	0.22	15
NG-150-FGR	0.26	0.18	31
NG-150-RAP[c]	0.26	0.18	31
NG-400-LEA	0.26	0.22	15
NG-400-FGR	0.26	0.18	31
NG-400-RAP[c]	0.26	0.18	31

[a] All coal-fired boilers fire high sulfur coal.

[b] Uncontrolled boilers employ combustion air preheaters which preheat combustion air to 300°F.

[c] RAP boilers do not employ air preheaters and use ambient combustion air (77°F).

As with the boiler, PM control, and SO_2 control costs, the costs of NO_x control are estimated by the use of cost algorithms. These algorithms present particular NO_x control cost components as a function of key system specifications. Tables A-24 through A-28 of Appendix A present a listing of the algorithms for each NO_x control analyzed in this chapter. The development and cost bases for these algorithms are presented in a Radian technical memorandum.[4] The cost calculation methodology for the NO_x control costs presented in this chapter is the same as that presented in Chapter 2 for the boilers, PM controls, and SO_2 controls.

Table 5-2 presents the specifications and the recommended equipment needed when implementing the NO_x controls. These items are the basis for the capital cost algorithms. All of the NO_x controls except for RAP require additional equipment and/or boiler modifications. For residual oil-fired boilers, a slightly larger firebox is required when SCA is applied because the staging causes an extension of the boiler flame. To accommodate the longer flame a larger boiler firebox is required. The degree of staging required to meet a given emission level depends on the residual oil nitrogen content.

For RAP, the cost algorithm presented predicts only the incremental fuel cost associated with not recovering heat from the boiler flue gas. In many cases, other means of heat recovery may be available (such as economizers) to reduce or eliminate this heat loss without affecting NO_x emissions.

The major annual O&M cost components are maintenance labor, maintenance materials, spare parts, fuel, and electricity. The maintenance labor, maintenance materials and spare parts cost components are combined and calculated using the spare parts cost algorithms. The fuel costs are based on a change in boiler efficiency due to the implementation of the NO_x control. When LEA is used, boiler efficiency increases, therefore a fuel savings results. The other three NO_x controls decrease boiler efficiency which result in higher fuel costs. The fuel cost algorithms for LEA and RAP are based on changes in excess air levels and flue gas temperatures. For

TABLE 5-2. NO_x COMBUSTION MODIFICATION EQUIPMENT REQUIREMENTS OR MODIFICATIONS[a]

Control Device		
Low Excess Air (LEA)		Oxygen trim system - O_2 analyzer, air flow regulators Wind box modifications (may be required for multi-burner boilers)
Staged Combustion Air (SCA)	Pulverized coal-fired boilers	Oxygen trim system - O_2 analyzer, air flow regulators Airports Wind box modifications Larger forced draft fan power
	Residual oil-fired boilers	Up to 30 percent larger boiler to accommodate longer flame
Flue gas recirculation (FGR)		Larger forced draft fan and associated ductwork Modification of wind box and burners to handle additional gas flow Control system to regulate combustion oxygen and the volume of flue gas recirculated
Reduced Air Preheat (RAP)		No additional equipment or modifications required

[a] Continuous NO_x monitors are not included in these cost algorithms.

SCA and FGR a 0.25 percent and 0.5 percent decrease in boiler efficiency, respectively, is assumed (See Appendix A).

The use of SCA and FGR also results in higher fan power requirements which increases the amount of electricity required. The cost of electricity if assumed to be \$0.026/kwh. Several key variables in the cost algorithms were assumed in this cost analysis. Table 5-3 presents the costs of the fuels used along with the capacity utilization for the boilers to which the NO_x controls are applied. The fuel prices are 1990 prices in 1978 dollars and are consistent with the fuel prices presented in Chapter 2.

For the calculation of LEA and RAP fuel costs, fuel F-factor calculations and boiler excess air levels are used in the cost algorithms to determine flue gas flow rates. Table 5-4 presents the selected values for these variables. For RAP, it was assumed that the boiler was operating under controlled excess air conditions and the change in flue gas temperature was 100°F.

In the calculation of annualized costs a capital recovery factor of 13.15 percent was used. This factor is based on a real interest rate of 10 percent and a 15 year equipment life. This is the same capital recovery component that was used in the SO_2 and PM control cost analyses. The other capital related charges are also the same as in the previous analyses. Taxes, G&A, and insurance are 4 percent of total turnkey costs which interest on working capital is 10 percent.

5.3 ANALYSIS OF COST IMPACTS

Table 5-5 presents the costs of NO_x control for the control cases presented in Table 5-1. The costs are divided into capital costs, annual O&M costs, total annualized costs and normalized annualized costs. The normalized annualized costs provide a size independent measure of the annualized costs. They are calculated by dividing the total annualized costs of the control by the total annual heat input to the boiler. The final unit is $\$/10^6$ Btu.

Low excess air (LEA) is the least expensive combustion modification because it improves boiler efficiency thus reducing boiler fuel costs. The

TABLE 5-3. FUEL COSTS AND CAPACITY FACTORS USED FOR NO_x CONTROL COST ESTIMATION[2,3]

Fuel Type	Nitrogen Content (wt. %)	Fuel Cost $\$/10^6$ Btu	Capacity Utilization (-)
High sulfur coal	1.2	2.41	0.60
Residual oil	0.4	4.85	0.55
Distillate oil	Trace	6.06	0.55
Natural gas	8.05[a]	4.85	0.55

[a] Unbound nitrogen, not fuel N_2 that can be converted to "fuel" NO_x emissions.[8]

TABLE 5-4. FUEL F-FACTORS AND BOILER EXCESS AIR LEVELS USED IN NO_x CONTROL COST ESTIMATION

Fuel Type	F-Factor ($dscf/10^6$ Btu)	Uncontrolled Boiler [% Excess Air (% O_2)]	Controlled Boiler [% Excess Air (% O_2)]
High sulfur coal	9,820	50 (6.7)	35 (5.2)
Residual and Distillate oil	9,220	38.4 (6)	9.1 (2)
Natural gas	8,740	37.4 (6)	8.5 (2)

TABLE 5-5. NO_x CONTROL COSTS (MID-1978 $)

Control Case	Capital Costs, $	Annual O&M Costs, $/yr	Total Annualized Costs, $/yr	Normalized Annualized Costs, $/$10^6$ Btu[a]
Coal				
UNDR-30-LEA	11,600	-1,910	76	neg
UNDR-75-LEA	15,200	-5,640	-3,020	-0.008
SPRD-150-LEA	21,300	-11,900	-8,190	-0.01
SPRD-250-LEA	29,500	-20,100	-15,100	-0.01
PLVR-150-LEA	21,300	-11,900	-8,190	-0.01
PLVR-150-SCA	43,700	15,600	22,800	0.03
PLVR-250-LEA	29,500	-20,100	-15,100	-0.01
PLVR-250-SCA	60,300	23,400	33,400	0.03
PLVR-400-LEA	41,600	-32,600	-25,400	-0.01
PLVR-400-SCA	86,100	39,600	53,800	0.03
0.2% Nitrogen Residual Oil				
RES-30-LEA	9,150	-11,300	-9,740	-0.07
RES-150-LEA	15,300	-58,500	-55,900	-0.08
RES-250-LEA	20,400	-97,800	-94,300	-0.08
0.4% Nitrogen Residual Oil				
RES-30-SCA	58,600	7,040	17,000	0.12
RES-150-SCA	150,000	26,400	51,800	0.07
RES-250-SCA	227,000	42,400	80,800	0.07

TABLE 5-5. (Continued)

Control Case	Capital Costs, $	Annual O&M Costs, $/yr	Total Annualized Costs, $/yr	Normalized Annualized Costs, $/$10^6$ Btu[a]
Distillate Oil				
DIS-30-LEA	9,150	-14,300	-12,700	-0.09
DIS-30-FGR	19,600	9,600	12,900	0.09
DIS-30-RAP	1,450	17,400	17,500	0.12
DIS-150-LEA	15,300	-73,300	-70,700	-0.10
DIS-150-FGR	36,800	43,900	49,700	0.07
DIS-150-RAP	7,230	86,800	87,500	0.12
DIS-250-LEA	20,400	-123,000	-119,000	-0.10
DIS-250-FGR	51,100	72,500	80,400	0.07
DIS-250-RAP	12,000	145,000	146,000	0.12
Natural Gas				
NG-30-LEA	9,200	-10,500	-8,970	-0.06
NG-30-FGR	19,500	8,700	12,000	0.08
NG-30-RAP	1,090	13,100	13,200	0.09
NG-150-LEA	15,300	-54,600	-54,000	-0.07
NG-150-FGR	36,400	39,500	45,300	0.06
NG-150-RAP	5,460	65,500	66,000	0.09
NG-250-LEA	20,800	-91,400	-87,900	-0.07
NG-250-FGR	50,500	65,200	73,000	0.06
NG-250-RAP	9,090	109,000	110,000	0.09

[a] Negative number indicates net savings due to application of the control.

cost of applying LEA ranges from a savings of \$119,000/year on a 250×10^6 Btu/hr distillate oil-fired boiler to a cost of \$76/year on a 30×10^6 Btu/hr underfired coal-fired unit.

The application of either staged combustion air (SCA), flue gas recirculation (FGR), or reduced air preheat (RAP) increases annualized costs. The application of SCA on residual oil-fired boilers is more expensive than SCA on pulverized coal-fired boilers. This higher cost occurs because staging on residual oil-fired boilers requires larger boiler fireboxes. The increase in annualized costs due to SCA on pulverized coal-fired boilers ranges from \$22,800/year on a 150×10^6 Btu/hr boiler to \$53,800/year on a 400×10^6 Btu/hr boiler. For residual oil-fired units the cost of applying SCA ranges from \$17,000/year on a 30×10^6 Btu/hr unit firing 2 weight percent nitrogen oil to \$81,000/year on a 250×10^6 Btu/hr unit firing 4 weight percent nitrogen oil.

The increase in costs due to the application of FGR on distillate oil- and natural gas-fired boilers ranges from \$12,000/year on a 30×10^6 But/hr natural gas-fired boiler to \$80,400/year on a 250×10^6 Btu/hr distillate oil-fired boiler. For RAP the increased cost for distillate oil-and natural gas-fired boilers ranges from \$13,200/year on a 30×10^6 Btu/hr natural gas-fired boiler to \$146,000/year on a 250×10^6 Btu/hr distillate oil-fired unit. For both of these controls, the fuel penalty and therefore control costs are higher on distillate oil-fired units because of the higher price of distillate oil (See Table 5-3).

5.4 References

1. U.S. Environmental Protection Agency. Fossil Fuel Fired Industrial Boilers-Background Information. Volume 1. Research Triangle Park, N.C. Publication No. EPA-450/3-82-006a. March 1982. 869 p.

2. Memo from Lahre, T., EPA:SAS to Sedmon, C., EPA:EMB. October 1, 1981. 35 p. Review of Coal Combustion Section, Revisions to Section 1.1 of AP.42.

3. Burklin, C.E., and W.D. Kwapil. (Radian Corporation.) Regressions for NO_x Emissions from Oil- and Gas-Fired Boilers. (Prepared for U.S. Environmental Protection Agency.) Research Triangle Park, N.C. May 27, 1982. 49 p.

4. Memo from Bowen, M.L., Radian Corporation, to Jones, L., EPA:SDB. July 28, 1982. 12 p. NO_x Combustion Modification Cost Algorithm Development.

6.0 COSTS OF LOW SULFUR COAL AND LOW SULFUR OIL

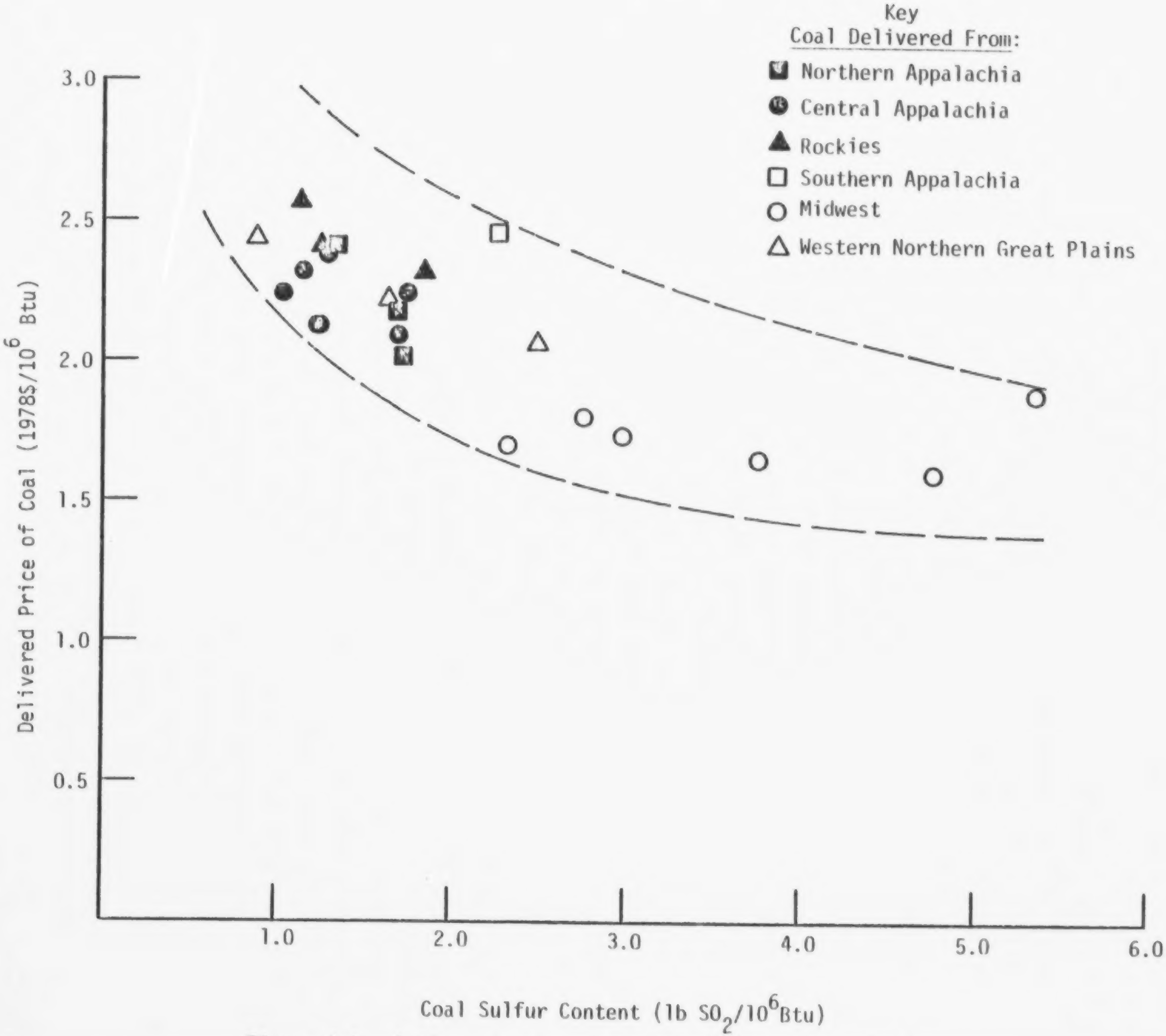
This section discusses the costs of using low sulfur coal or low sulfur oil (hydrodesulfurized oil) to reduce SO_2 emissions from industrial boilers. The costs are presented in constant 1978 dollars and are projected for the year 1990.

Estimation of the cost of using low sulfur fuels is complicated by site specific factors. In the case of low sulfur coal, the delivered price of the fuel is a strong function of boiler location and the availability of coal with a desired sulfur content. The delivered price of low sulfur fuel oil also depends on boiler location, as well as the available refinery hydrodesulfurization capacity to produce oil with the desired sulfur content. A complete analysis of the availability of low sulfur fuels to industrial users is beyond the scope of this report. The costs presented in this chapter are based primarily on projected fuel and transportation costs used in the Industrial Fuel Choice Analysis Model (IFCAM). Documentation of the methods of projection and assumptions used to develop these prices are contained in Chapter 10 of the Background Information Document for Industrial Boilers.[1]

6.1 LOW SULFUR COAL

Figure 6-1 shows the delivered cost of coal supplied to a boiler in the midwestern United States as a function of coal sulfur content and coal supply region. Low sulfur coal (less than 2.5 lb $SO_2/10^6$ Btu) is typically supplied from regions other than the Midwest and transportation costs are a major component of the delivered price for these fuels. Higher sulfur coals would likely be obtained from local (Midwest) supplies.

The broad region formed by the two curves in Figure 6-1 is intended to represent an approximate range of coal prices as a function of sulfur content for the Midwest location. Using these values, one can compare the cost of using coal with a specific sulfur content to the annualized cost of FGD systems as a function of boiler size (Figure 6-2). Figure 6-2 is based on a double alkali FGD system operating at 90 percent SO_2


Key
Coal Delivered From:
■ Northern Appalachia
● Central Appalachia
▲ Rockies
□ Southern Appalachia
○ Midwest
△ Western Northern Great Plains
Delivered Price of Coal (1978$/10^6 Btu)
3.0
2.5
2.0
1.5
1.0
0.5
1.0
2.0
3.0
4.0
5.0
6.0
Coal Sulfur Content (lb SO2/10^6Btu)

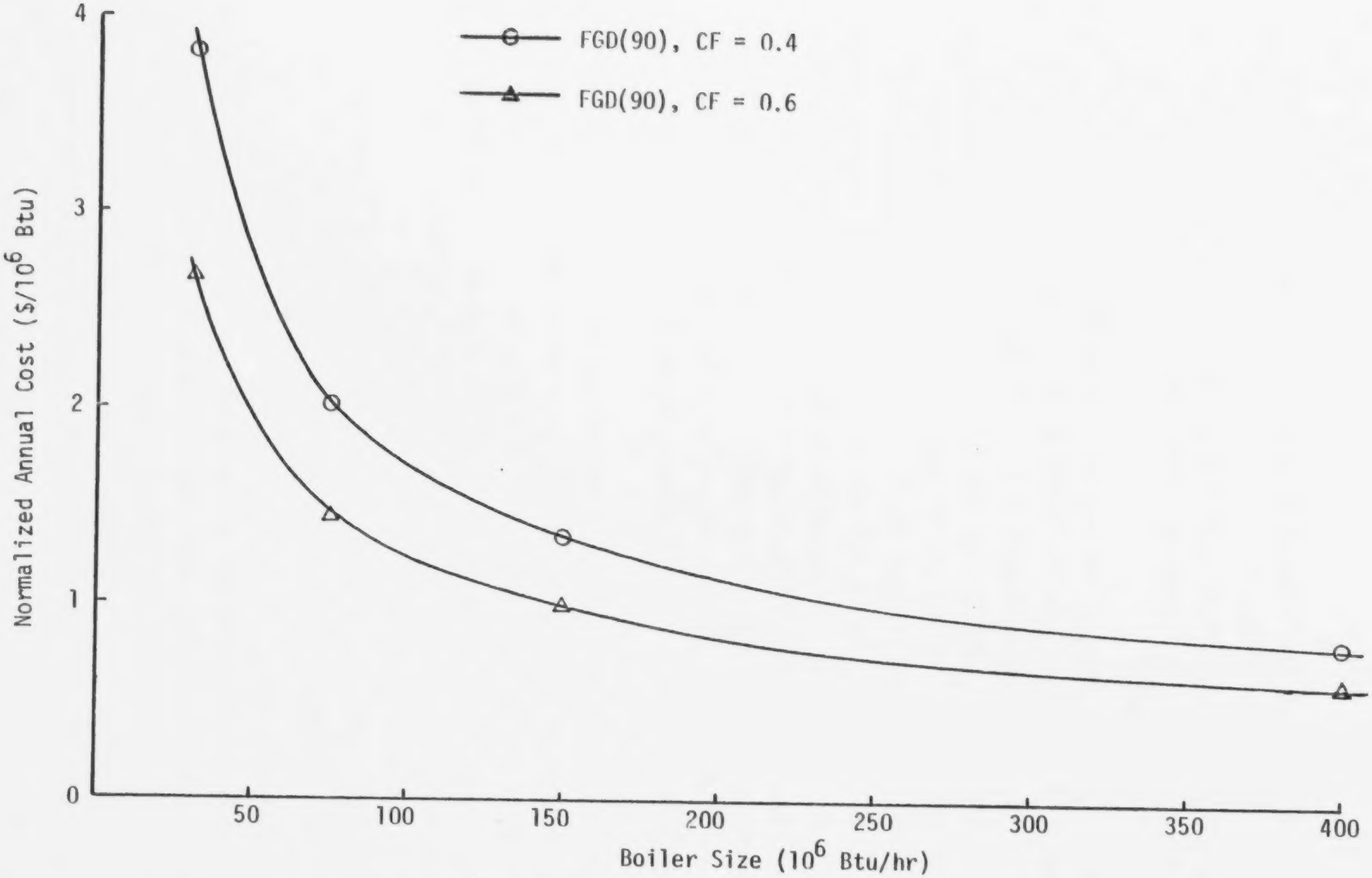


Figure 6-2. Normalized annualized cost of FGD system applied to HSC coal-fired boilers.

removal on a boiler firing 3.5 percent sulfur coal (0.6 lb $SO_2/10^6$ Btu controlled emissions). Unlike the use of low sulfur coal, normalized annualized costs for FGD systems ($\$/10^6$ Btu) are a function of boiler size and capacity factor. Figure 6-2 shows costs for both 0.4 and 0.6 capacity factor cases.

For example, the 1990 cost of coal with emissions of about 1.2 lb $SO_2/10^6$ Btu delivered to a Midwest boiler range from about \$2.00 to $\$2.50/10^6$ Btu according to Figure 6-1. This can be compared to the annualized cost of a 90 percent SO_2 removal FGD system on a 0.6 capacity factor unit burning 3.5 percent sulfur coal shown in Figure 6-2. The FGD system costs ranges from about $\$0.60/10^6$ Btu for a 400 x 10^6 Btu/hr unit to $\$2.70/10^6$ Btu for a 30 x 10^6 Btu/hr boiler.

As discussed earlier, the delivered price of coal is a function of boiler location. Figure 6-3 shows the delivered cost of coal to a boiler located in the Southwest (Houston). Because of the greater distances over which coal from the supply regions indicated in the figure must be transported, delivered coal prices are slightly higher than for the Midwest location.

Figure 6-4 shows the delivered price of coal to a Northeast location (Boston). Comparison of Figures 6-3 and 6-4 with Figure 6-1 shows that the variation in the delivered price of coal as a function of sulfur content is strongest in the Midwest. There are no clear trends in coal price variation with sulfur content when the coal is delivered to a Southwest or Northeast location.

It should be noted that these conclusions are based on a limited number of coals included in the IFCAM model.[1]

6.2 LOW SULFUR FUEL OIL

The cost of residual oil can be expressed as a function of sulfur content as shown in Table 6-1. The range of costs shown in this table are based on premiums associated with the desulfurization of crudes with different metal contents, a factor which impacts the desulfurization costs. Calculation of these premiums is documented in a separate paper.[2]

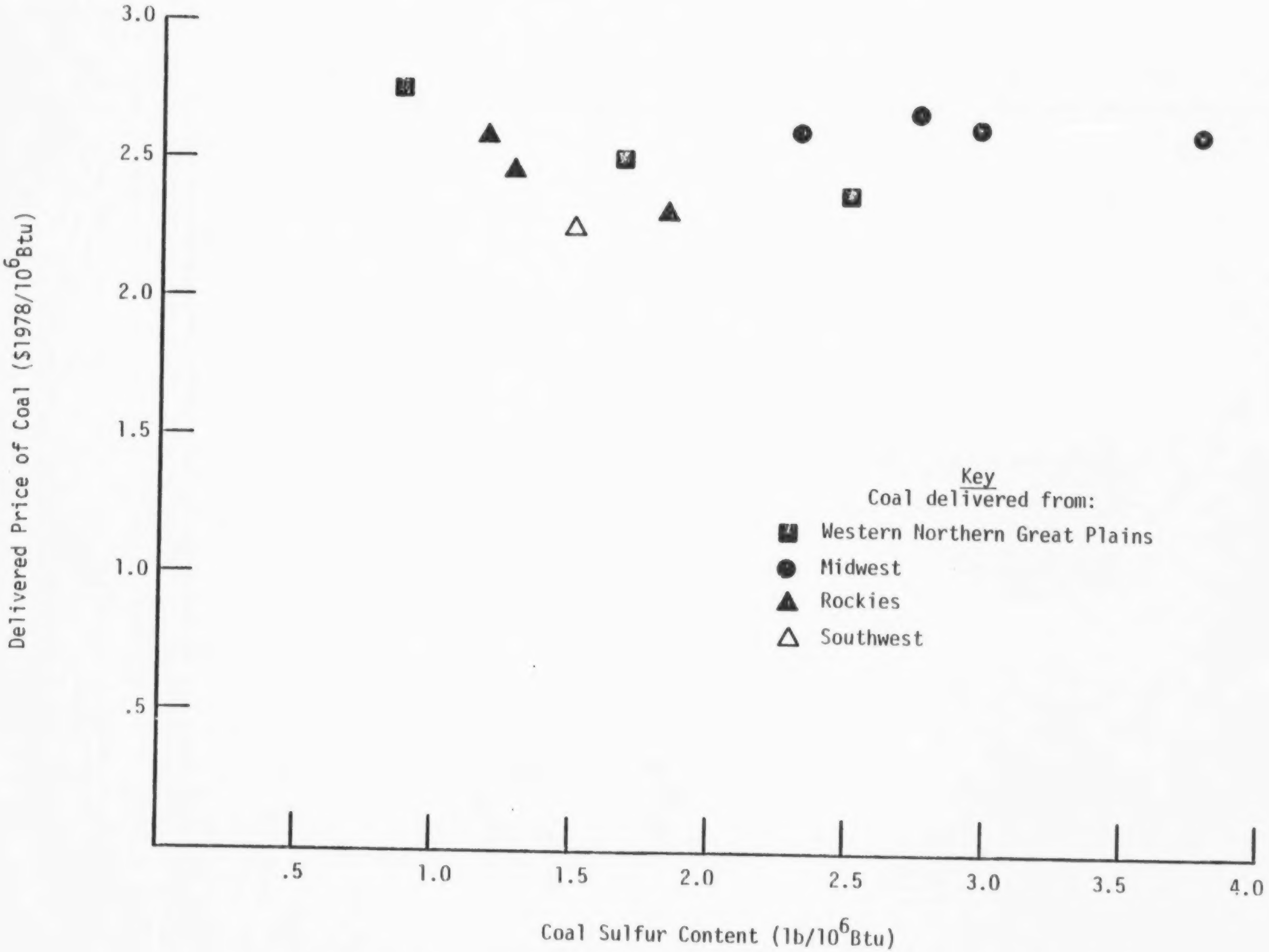


Figure 6-3. Delivered price of coal to a Southwest location (Houston).

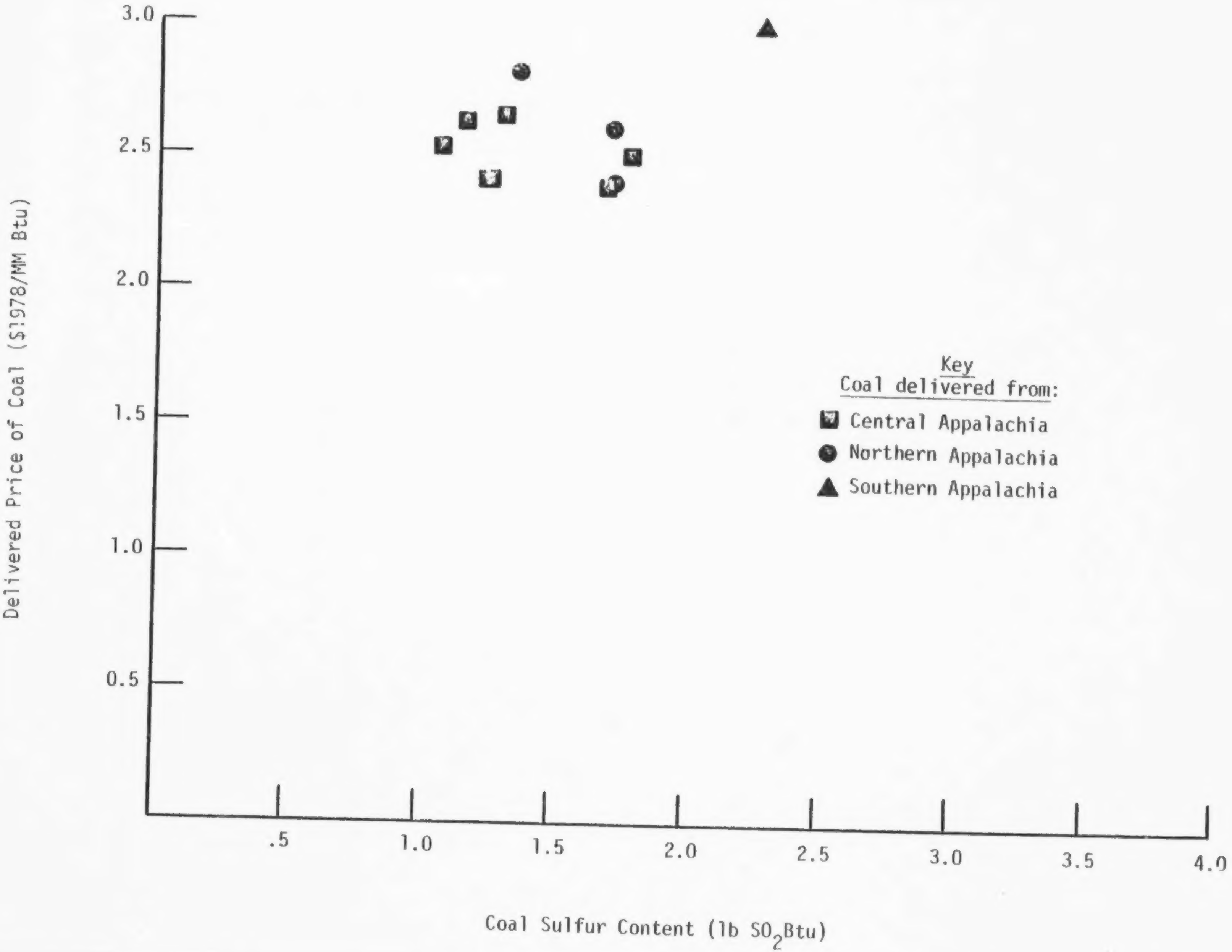

3.0
2.5
2.0
1.5
1.0
0.5
Delivered Price of Coal ($1978/MM Btu)
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Coal Sulfur Content (lb SO_2Btu)
Key
Coal delivered from:
Central Appalachia
Northern Appalachia
Southern Appalachia

TABLE 6-1. INCREMENTAL INCREASES IN RESIDUAL OIL PRICES FOR VARIOUS SULFUR CONTENTS

Sulfur content of oil (weight %)	Incremental Cost of Desulfurization[a] ($/$10^6$ Btu)
0.8	0.68 - 0.74
0.3	0.93 - 1.03
0.1	1.03 - 1.39

[a] Added cost of hydrodesulfurization of 3% sulfur feedstock crude.

This paper also discusses trends in petroleum product supply and demand and compares the costs, energy, and environmental impacts of FGD and the use of low sulfur hydrodesulfurized fuel oil (HDS).

6.3 REFERENCES

1. Energy and Environmental Analysis. Background Information Document for Industrial Boilers, Chapter 10 (Draft). March 1981.

2. Menzies, W.R. (Radian Corporation). Issue Paper No. 5: SO_2 Standard for Oil. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C. EPA Contract No. 68-02-3074. November 3, 1980. 34 p.

APPENDIX A

COST ALGORITHMS

Appendix A presents the cost algorithms used to calculate the boiler, PM control, SO_2 control, and NO_x control costs presented in Chapters 3, 4 and 5. Table A-1 summarizes the costing algorithms available. The algorithms are presented as routines (UNDR, VS, DAC, etc.) to identify them in the FORTRAN computer program (COST) used to calculate costs. This program is presented in Appendix B. All the algorithms are used in this analysis with the exception of the distillate/natural gas boiler routines (DNG1, DNG2) and the dual mechanical collector PM control routine (DM). These algorithms are presented for reference since they were developed in conjunction with the other routines.

Table A-2 presents the nomenclature used in the costing algorithms. Categories 1-3 are costs, while the remaining categories are boiler and pollution control system specifications and cost rates used to calculate costs. The costing algorithms presented use this nomenclature. In general, the FORTRAN program also uses this nomenclature. However, slight variations are made to facilitate computations. The major variation is the use of arrays to store cost components rather than using the individual variables in Table A-2.

Many cost calculations are common to nearly all algorithms. Rather than repeat these equations for each algorithm, Table A-3 presents these common equations. Slight variations from these calculations are found in some algorithms. In these cases, the equations presented in the individual algorithm are used rather than the equations in Table A-3.

TABLE A-1. SUMMARY OF COSTING ALGORITHMS

Routine Code[a]	Algorithm Type	Boiler Size Applicability (10^6 Btu/hr)	Table
UNDR	Boiler, underfeed stoker, watertube, package	≤75	A-4
SPRD	Boiler, spreader stoker, watertube, field-erected	60 - 200	A-5
PLVR	Boiler, pulverized coal, watertube, field-erected	≥200	A-6
RES1	Boiler, residual oil, firetube, package	≤30	A-7
RNG1	Boiler, residual/natural gas, watertube, package	30 - 200	A-8
RNG2	Boiler, residual/natural gas, watertube, field-erected	200 - 700	A-9
DNG1	Boiler, distillate/natural gas, firetube, package	≤30	A-10
DNG2	Boiler, distillate/natural gas, watertube, package	30 - 200	A-11
VS	Venturi scrubber applied to coal-fired boiler	30 - 700	A-12
ESPC	Electrostatic precipitator applied to coal-fired boiler	≤700	A-13
ESPO	Electrostatic precipitator applied to residual oil-fired boiler	≤700	A-14
FF	Fabric filter applied to coal-fired boiler	30 - 700	A-15
SM	Single mechanical collector (multi-cyclone) applied to coal-fired boiler	30 - 700	A-16
DM	Dual mechanical collector (multi-cyclones) applied to coal-fired boiler	30 - 700	A-17
SSS	Sidestream separator applied to coal-fired boiler	30 - 700	A-18
DA	Dual alkali FGD system without PM removal	All sizes	A-19
DAC	Dual alkali FGD system with PM removal	All sizes	A-20
NATH	Sodium throwaway FGD system	All sizes	A-21
DS	Lime spray drying (dry scrubbing) FGD system	All sizes	A-22

TABLE A-1. (Continued)

Routine Code[a]	Algorithm Type	Boiler Size Applicability (10^6 Btu/hr)	Table
LEA	Low excess air applied to all fuel types	All sizes	A-24
SCA	Staged combustion air applied to pulverized coal-fired boiler	>150	A-25
SCA	Staged combustion air applied to residual oil-fired boiler	30 - 250	A-26
FGR	Flue gas recirculation applied to distillate oil- and natural gas-fired boiler	30 - 250	A-27
RAP	Reduced air preheat applied to all fuel types	All sizes	A-28

[a] Routine code refers to code used to identify algorithm in FORTRAN computer program (see Appendix B).

TABLE A-2. NOMENCLATURE USED IN COST ALGORITHMS

1. Capital Costs (1978 dollars)

EQUP = Equipment
INST = Installation
TD = Total Direct
IND = Indirect (Engineering, Field, Construction, Start-up, and other miscellaneous costs)
TDI = Total Direct and Indirect
CONT = Contingencies
TK = Turnkey
LAND = Land
WC = Working Capital
TOTL = Total Capital

2. Operation and Maintenance Costs[a] (1978 dollars/year)

DL = Direct Labor
SPRV = Supervision Labor
MANT = Maintenance Labor
SP = Spare Parts
ELEC = Electricity
UC = Utilities and Chemicals
WTR = Water
SW = Solid Waste Disposal
SLG = Sludge Waste Disposal
LW = Liquid Waste Disposal
SC = Sodium Carbonate
LMS = Limestone
LIME = Lime
FUEL = Fuel
TDOM = Total Direct Operation and Maintenance
OH = Overhead
TOTL = Total Operation and Maintenance

3. Annualized Costs (1978 dollars/year)

CR = Capital Recovery
WCC = Working Capital Charges
MISC = Miscelleneous (G & A, Taxes, Insurance)
TCC = Total Capital Charges
TOTL = Total Annualized Charges

TABLE A-2. (Continued)

4. Boiler Specifications

Q = Thermal Input (10^6 Btu/hr) (MW)[c]
FLW = Flue Gas Flowrate (acfm) (m^3/s)[c]
CF = Capacity Factor (-)[d]
BCRF = Capital Recovery Factor for Boiler System

5. Fuel Specifications

FC = Fuel Cost ($\$/10^6$ Btu) ($/MJ)[c]
H = Heating Value (Btu/lb) (KJ/kg)[c]
S = Sulfur Content (percent by weight)
A = Ash Content (percent by weight)
N = Fuel Nitrogen Content (percent by weight)

6. SO_2 Control Specifications

UNCSO2 = Uncontrolled SO_2 Emissions (lb/10^6 Btu) (ng/J)[c]
CTRSO2 = Controlled SO_2 Emissions (lb/10^6 Btu) (ng/J)[c]
EFFSO2 = SO_2 Removal Efficiency (percent)
CRFSO2 = Capital Recovery Factor for SO_2 Control System

7. PM Control Specifications

UNCPM = Uncontrolled PM Emissions (lb/10^6 Btu) (ng/J)[c]
CTRPM = Controlled PM Emissions (lb/10^6 Btu) (ng/J)[c]
EFFPM = PM Removal Efficiency (percent)
CRFPM = Capital Recovery Factor for PM Control System

8. Cost Rates (used in FGD algorithms)[b,c]

ELECR = Electricity Rate ($/kw-hr)
WTRR = Water Rate ($\$/m^3$)
ALIMER = Lime Rate ($/kg)
ALSR = Limestone Rate ($/kg)
SASHR = Sodium Carbonate Rate ($/kg)
SLDGR = Sludge Disposal Rate ($/kg)
SWDR = Solid Waste Disposal Rate ($/kg)
LWDR = Liquid Waste Disposal Rate ($\$/m^3$)

9. Miscellaneous

S1 = Heat Specific Sulfur Removal (kg SO_2/100 MJ)
S2 = Time Specific Sulfur Removal (kg SO_2/0.1 hr)
LF = Labor Factor (-)[d]

TABLE A-2. (Continued)

10. NO_x Control Specifications

FFAC = F-Factor (dscf/10^6 Btu)
UNCEA = Uncontrolled Excess Air (%)
CTREA = Controlled Excess Air (%)
PRCT = Percent Flame Extension Due to Staging
DELT = Change in the flue gas exit temperature due to the elimination of the air preheater or a reduction in its effectiveness
$CRFNO_x$ = Capital Recovery Factor for NO_x Control System

---

[a] Cost categories are not mutually exclusive. For example, some costing routines include electricity and waste cost in the utilities category while other calculate these cost separately.

[b] All other algorithms assume these rates to be constants; FGD algorithms allow the rates to be varied.

[c] FGD algorithms use metric units.

[d] (-) factor presented as fraction not as percent.

TABLE A-3. CALCULATIONS COMMON TO COST ALGORITHMS

1. Capital Costs

EQUP + INST = TD[a]
IND = 0.333 * TD[b]
TDI = TD + IND
CONT = 0.20 * TDI
TK = TDI + CONT
LAND[c] = $4000 pulverized coal boilers
= $2000 all other boilers
WC = 0.25 * (TDOM - Fuel) + 0.0833 (Fuel)[d]
TOTL = TK + LAND + WC

2. Operation and Maintenance Costs

FUEL = CF * Q * FC * 8760
TDOM = Sum of all O & M Costs other than OH
OH = 0.30 * DL + 0.26 * (DL + SPRV + MANT + SP)
TOTL = TDOM + OH

3. Annualized Costs

CR = CRF * TK
WCC = 0.10 * WC
MISC = 0.04 * TK
TCC = CR + WCC + MISC
TOTL = TCC + TOTL O & M Costs

4. Labor Factors

LF = 1 if CF >0.7
LF = 0.5 + 2.5 * (CF - 0.5) if 0.5 ≤CF ≤0.7
LF = 0.5 if CF <0.5

---

[a] FGD system cost algorithms compute TD without prior computation of EQUP and INST

[b] Some algorithms compute IND explicitly as a function of boiler and/or control device specifications.

[c] Only boilers have costs assumed for land.

[d] For boilers, assume a 3 month supply of all working capital components except fuel which will have a 1 month supply. For control devices, working capital is 25% of total direct operating and maintenance costs.

Table A-4 through A-11 present the boiler cost algorithms. Table A-12 through A-18 and Tables A-19 through A-22 list the PM control and SO_2 control cost algorithms, respectively. Table A-23 presents the algorithms used to calculate flue gas flowrates for the standard boilers and Tables A-24 through A-28 present the NO_x control cost algorithms.

TABLE A-4. COST EQUATIONS FOR PACKAGE, WATERTUBE UNDERFEED STOKER BOILERS
($\leq 75 \times 10^6$ Btu/hr)[1]

Routine Code: UNDR

Capital Costs:

$$\text{EQUP} = 66{,}392\ Q^{0.622}\ \left(\frac{11{,}800}{H}\right) + 2{,}257\ Q^{0.819}$$

$$\text{INST} = 53{,}219\ Q^{0.65}\ \left(\frac{11{,}800}{H}\right) + 2{,}882\ Q^{0.796}$$

$$\text{IND} = 40{,}188\ Q^{0.646}\ \left(\frac{11{,}800}{H}\right)^{0.926}$$

Annual Costs:[a]

$$\text{DL} = \text{LF}\ (38{,}020\ \ln Q + 28{,}640)(0.767)$$

$$\text{SPRV} = \text{LF}\ \left(\frac{Q + 5{,}300{,}000}{99.29 - Q}\right)(0.767)$$

$$\text{MANT} = \text{LF}\ \left(\frac{Q + 4{,}955{,}000}{99.29 - Q}\right)(0.767)$$

$$\text{SP} = (1.705 \times 10^{8}\ Q - 2.959 \times 10^{8})^{0.5}\ \left(\frac{11{,}800}{H}\right)^{1.0028}(0.767)$$

$$\text{UC} = \frac{\text{CF}}{.6}\ \left(\frac{Q}{1.105 \times 10^{-5}\ Q + 3.69 \times 10^{-4}}\right)\ \left(\frac{11{,}800}{H}\right)^{0.9}\ \left(\frac{A}{10.6}\right)^{0.3}(0.848)$$

$$\text{SW} = \text{CF}\ (443.3)\ Q\ \left(\frac{11{,}800}{H}\right)^{0.9}\ \left(\frac{A}{10.6}\right)^{0.3}(0.848)$$

---

[a] The multipliers used, 0.767 and 0.848, are included in determining annual O&M costs. These factors reflect the economies of multiple boilers at a facility (see Chapter 2).

TABLE A-5. COST EQUATIONS FOR FIELD-ERECTED, WATERTUBE SPREADER-STOKER BOILERS

$(60\text{-}200 \times 10^6$ Btu/hr$)^1$

Routine Code: SPRD

Capital Costs:

$$EQUP = \left(\frac{Q}{7.5963 \times 10^{-8}\ Q + 4.7611 \times 10^{-5}}\right) \left(\frac{H}{11,800}\right)^{-.35}$$

$$INST = \left(\frac{Q}{8.9174 \times 10^{-8}\ Q + 5.5891 \times 10^{-5}}\right) \left(\frac{H}{11,800}\right)^{-.35}$$

$$IND = \left(\frac{Q}{1.2739 \times 10^{-7}\ Q + 7.9845 \times 10^{-5}}\right) \left(\frac{H}{11,800}\right)^{-.35}$$

Annual Costs:[a]

$DL = LF\ (202,825 + 5.366\ Q^2)\ (0.767)$

$SPRV = LF\ (136,900)\ (0.767)$

$MANT = LF\ (107,003 + 1.873\ Q^2)\ (0.767)$

$SP = 50,000 + 1,000\ Q\quad (0.767)$

$UC = CF\ (29,303 + 719.8\ Q)\ (0.848)$

$SW = 0.38\ CF\ (547,320 + 66,038\ \ln \frac{A}{H})\ (\frac{Q}{150})^{0.9754}\ (0.848)$

---

[a] The multipliers used, 0.767 and 0.848, are included in determining annual O&M costs. These factors reflect the economies of multiple boilers at a facility (see Chapter 2).

TABLE A-6. COST EQUATION FOR FIELD-ERECTED, WATERTUBE PULVERIZED COAL-FIRED BOILERS

$(\geq 200 \times 10^6$ Btu/hr$)^1$

Routine Code: PLVR

Capital Costs:

$$\text{EQUP} = (4{,}926{,}066 - 0.00337\ H^2)\ \left(\frac{Q}{200}\right)^{0.712}$$

$$\text{INST} = 1{,}547{,}622.7 + 6{,}740.026\ Q - 0.0024133\ H^2$$

$$\text{IND} = 1.257{,}434.72 + 6{,}271.316\ Q - 0.00185721\ H^2$$

Annual Costs:[a]

$$\text{DL} = \text{LF}\ (244{,}455 + 1{,}157\ Q)\ (0.767)$$

$$\text{SPRV} = \text{LF}\ \left(243{,}985 - \frac{20{,}636{,}709}{Q}\right)(0.767)$$

$$\text{MANT} = \text{LF}\ (-1{,}162{,}910 + 256{,}604\ \ln Q)\ (0.767)$$

$$\text{SP} = (180{,}429 + 405.4\ Q)\ (0.767)$$

$$\text{UC} = \text{CF}\ (189{,}430 + 1476.7\ Q)(0.848)$$

$$\text{SW} = 0.38\ \text{CF}\ \left(-641.08 + \frac{70{,}679{,}828\ A}{H}\right)\ \left(\frac{Q}{200}\right)^{1.001}(0.848)$$

---

[a] The multipliers used, 0.767 and 0.848, are included in determining annual O&M costs. These factors reflect the economies of multiple boilers at a facility (see Chapter 2).

TABLE A-7. COST EQUATIONS FOR PACKAGE, FIRETUBE, RESIDUAL OIL-FIRED BOILERS ($\leq 30 \times 10^6$ Btu/hr)[1]

Routine Code: RES1

Capital Costs:

$\text{EQUP} = 17{,}360\ Q^{0.557}$

$\text{INST} = 4{,}324\ Q + 56{,}177$

$\text{IND} = 2{,}317\ Q + 29{,}749$

Annual Costs:[a]

$\text{DL} = \text{LF}\ (105{,}300)(0.799)$

$\text{SPRV} = \text{LF}\ (\frac{Q-5}{10})\ (68500)\ (0.799)$ if $Q < 15$

$\text{LF}\ (68{,}500)\ (0.799)$ if $Q \geq 15$

$\text{MANT} = \text{LF}\ (1{,}600\ Q + 8{,}000)(0.799)$ if $Q < 15$

$\text{LF}\ (32{,}000)(0.799)$ if $Q \geq 15$

$\text{UC} = \frac{\text{CF}}{.45}\ (580\ Q + 3{,}900)\ (0.845)$

---

[a] The multipliers used, 0.799 and 0.845, are included in determining annual O&M costs. These factors reflect the economies of multiple boilers at a facility (see Chapter 2).

TABLE A-8.. COST EQUATIONS FOR PACKAGE, WATERTUBE DUAL-FIRED BOILERS FIRING RESIDUAL OIL/NATURAL GAS ($30-200 \times 10^6$ Btu/hr)[1]

Routine Code: RNG1

Capital Costs

$$EQUP = 15{,}925\ Q^{.775}$$

$$INST = 54{,}833\ Q^{0.364}$$

$$IND = 16{,}561\ Q^{.613}$$

Annual Costs [a]

$$DL = LF\left(\frac{Q^2}{8.135 \times 10^{-4}\ Q - 1.585 \times 10^{-2}}\right)(0.799)$$

$$SPRV = LF\ (68{,}500)(0.799)$$

$$MANT = LF\left(\frac{-1{,}267{,}000}{Q} + 77{,}190\right)(0.799)$$

$$SP = 7{,}185\ Q^{0.4241}\ (0.799)$$

$$UC = \frac{CF}{.55}\ (202\ Q + 24{,}262)(0.845)$$

---

[a] The multipliers used, 0.799 and 0.845, are included in determining annual O&M costs. These factors reflect the economies of multiple boilers at a facility (see Chapter 2).

TABLE A-9. COST EQUATIONS FOR FIELD-ERECTED, WATERTUBE RESIDUAL OIL/GAS-FIRED BOILERS

$(200 - 700 \times 10^6$ Btu/hr$)^1$

Routine Code: RNG2

Capital Costs:

EQUP = 1,024,258 + 8,458 Q

INST = 579,895 + 5,636 Q

IND = 515,189 + 4,524 Q

Annual Costs:[a]

DL = LF (173,197 + 734 Q) (0.799)

SPRV = $LF\left(263{,}250 - \frac{30{,}940{,}000}{Q}\right)(0.799)$

MANT = LF (32,029 + 320.4 Q) (0.799)

SP = (50,000 + 250 Q) (0.799)

UC = CF (43,671.7 + 479.6 Q)(0.845)

---

[a] The multipliers used, 0.799 and 0.845, are included in determining annual O&M costs. These factors reflect the economies of multiple boilers at a facility (see Chapter 2).

TABLE A-10. COST EQUATIONS FOR PACKAGE, FIRETUBE, NATURAL GAS/DISTILLATE OIL-FIRED BOILERS ($\leq 30 \times 10^6$ Btu/hr)

Routine Code: DNG1

Capital Costs

$\text{EQUP} = 15{,}981\ Q^{0.561}$

$\text{INST} = 4{,}261\ Q + 56{,}041$

$\text{IND} = 2\ 256\ Q + 28{,}649$

Annual Costs[a]

$\text{DL} = \text{LF}\ (105{,}300)(0.799)$

$\text{SPRV} = \text{LF}\ \left(\frac{Q - 5}{10}\right)(68{,}500)(0.799)$ if $Q < 15$

$= \text{LF}\ (68{,}500)(0.799)$ if $Q \geq 15$

$\text{MANT} = \text{LF}\ (1600\ Q + 8000)(0.799)$ if $Q < 15$

$= \text{LF}\ (32{,}000)(0.799)$ if $Q \geq 15$

$\text{SP} = (708.7\ Q + 4{,}424)(0.799)$

$\text{UC} = \frac{\text{CF}}{.45}(580\ Q + 3{,}900)(0.845)$

---

[a] The multipliers used, 0.799 and 0.845, are included in determining annual O&M costs. These factors reflect the economies of multiple boilers at a facility (see Chapter 2).

TABLE A-11. COST EQUATIONS FOR PACKAGE, WATERTUBE, DUAL-FIRED BOILERS FIRING DISTILLATE OIL/NATURAL GAS (30 - 200 x 10^6 Btu/hr)

Routine Code: DNG2

Capital Costs:

EQUP = $14{,}850\ Q^{0.786}$

INST = $54{,}620\ Q^{0.361}$

IND = $15{,}952\ Q^{0.618}$

Annual Costs:[a]

$$\text{DL} = \text{LF}\left(\frac{Q^2}{8.135 \times 10^{-4}\ Q - 1.585 \times 10^{-2}}\right)(0.799)$$

$$\text{SPRV} = \text{LF}\ (68{,}500)(0.799)$$

$$\text{MANT} = \text{LF}\left(\frac{-1{,}267{,}000}{Q} + 77{,}190\right)(0.799)$$

$$\text{SP} = 7{,}185\ Q^{0.4241}\ (0.799)$$

$$\text{UC} = \frac{\text{CF}}{.55}(202\ Q + 24{,}262)(0.845)$$

---

[a] The multipliers used, 0.799 and 0.845, are included in determining annual O&M costs. These factors reflect the economies of multiple boilers at a facility (see Chapter 2).

TABLE A-12. COST EQUATIONS FOR VENTURI SCRUBBERS APPLIED TO COAL-FIRED BOILERS

($30 - 700 \times 10^6$ Btu/hr)[2]

Routine Code: VS

Capital Costs:

$\text{EQUP} = 26{,}916 + 2.294\ (\text{FLW})$

$\text{INST} = 13{,}904 + 1.653\ (\text{FLW})$

$\text{IND} = 15{,}463 + 1.285\ (\text{FLW})$

Annual Costs:

$\text{DL} = \text{LF}\ (10{,}150 + 106\ Q)$ if $30 \leq Q \leq 400$

$= \text{LF}\ (52{,}600)$ if $400 < Q \leq 700$

$\text{SPRV} = 0$ if $30 \leq Q \leq 400$

$= \text{LF}\ (17{,}000)$ if $400 < Q \leq 700$

$\text{SP} = 4{,}525 + 104.4\ Q$

$\text{UC} = \left(\frac{\text{CF}}{0.6}\right)\ (304.3\ Q^{0.938})$

$\text{SW} = \left(\frac{\text{CF}}{0.6}\right)\ 39.42\ (\text{UNCPM} - \text{CTRPM})$

TABLE A-13. COST EQUATIONS FOR ELECTROSTATIC PRECIPITATORS (ESP's) APPLIED TO COAL-FIRED BOILERS^2 ($\leq 700 \times 10^6$ Btu/hr)[a,b]

Routine Code: ESPC

Capital Costs:

EQUP	=	$0.02457\ (SCA)\ (FLW) - 5.62 \times 10^{-10} \times [(SCA)\ (FLW)]^2 +$	
		$0.544\ (FLW) + 26353$	if $30 \leq Q < 100$
	=	$0.02457\ (SCA)\ (FLW) - 5.62 \times 10^{-10} \times [(SCA)\ (FLW)]^2 +$	
		$(130{,}000 + 226\ Q)$	if $100 \leq Q \leq 700$ and $TPA \leq 28{,}000$
	=	$0.00965\ (SCA)\ (FLW) - 2.54 \times 10^{-11} \times [(SCA)\ (FLW)]^2 +$	
		$(130{,}000 + 226\ Q)$	if $100 \leq Q \leq 700$ and 28,000 TPA $\leq$
INST	=	1.17 EQUP	if $30 \leq Q < 100$
	=	1.10 EQUP	if $100 \leq Q \leq 700$

Annual Costs:

DL	=	LF [10,150 + 106Q]	if $30 \leq Q < 400$
	=	LF (52,600)	if $400 < Q \leq 700$
SPRV	=	0	if $30 \leq Q < 400$
	=	LF [17,000]	if $400 < Q \leq 700$
MANT	=	$LF\ [14{,}840 + 0.106\ Q^2]$	if $30 \leq Q < 400$
	=	LF (32,000)	if $400 < Q \leq 700$
SP	=	5.52×10^{-3} [EQUP + INST + IND]	
UC	=	$(\frac{CF}{0.6})$ [0.4068 (TPA) + 2.523 Q (UNCPM - CTRPM]	
SW	=	$(\frac{CF}{0.6})$ 39.42 Q [UNCPM - CTRPM]	

---

[a] SCA (ft^2/1000 acfm) = specific collection area =

$$[324.32\ S^{(-11.256 \times EFFPM^{-0.745})}]\ [(100-EFFPM)^{-0.366S^{-0.051}}]\ 1.18178$$

[b] TPA (ft^2) = total plate area = (SCA) (FLW)/1000

TABLE A-14. COST EQUATIONS FOR ELECTROSTATIC PRECIPITATORS (ESP's) APPLIED TO RESIDUAL OIL-FIRED BOILERS[2]

($\leq 700 \times 10^6$ Btu/hr)[a,b]

Routine Code: ESPO

Capital Costs:

$$\text{EQUP} = 0.02457\,(\text{SCA})\,(\text{FLW}) - 5.62 \times 10^{-10} \times [(\text{SCA})\,(\text{FLW})]^2 + [0.544\,(\text{FLW}) + 26{,}353] \qquad \text{if } 30 \leq Q < 100$$

$$= 0.02457\,(\text{SCA})\,(\text{FLW}) - 5.62 \times 10^{-10} \times [(\text{SCA})\,(\text{FLW})]^2 + [0.544\,(\text{FLW}) + 26{,}353] \qquad \text{if } 100 \leq Q \leq 700 \text{ and TPA} < 28{,}000$$

$$= 0.00965\,(\text{SCA})\,(\text{FLW}) - 2.54 \times 10^{-11} \times [(\text{SCA})\,(\text{FLW})]^2 + [0.544\,(\text{FLW}) + 26{,}353] \qquad \text{if } 100 \leq Q \leq 700 \text{ and } 28{,}000 \leq \text{TPA}$$

$$\text{INST} = 1.17\,(\text{EQUP}) \qquad \text{if } 30 \leq Q \leq 100$$

$$= 1.10\,(\text{EQUP}) \qquad \text{if } 100 < Q \leq 700$$

Annual Costs:

$$\text{DL} = \text{LF}\,[10{,}150 + 106\,Q] \qquad \text{if } 30 \leq Q \leq 400$$

$$= \text{LF}\,(52{,}600) \qquad \text{if } 400 < Q \leq 700$$

$$\text{SPRV} = 0 \qquad \text{if } 30 \leq Q \leq 400$$

$$= \text{LF}\,(17{,}000) \qquad \text{if } 400 < Q \leq 700$$

$$\text{MANT} = \text{LF}\,[14{,}840 + 0.106\,Q^2] \qquad \text{if } 30 \leq Q \leq 400$$

$$= \text{LF}\,(32{,}000) \qquad \text{if } 400 < Q \leq 700$$

$$\text{SP} = 5.52 \times 10^{-3}\,[\text{EQUP} + \text{INST} + \text{IND}]$$

$$\text{UC} = \left(\frac{\text{CF}}{0.6}\right)[0.4068\,(\text{TPA}) + 2.523\,Q\,(\text{UNCPM} - \text{CTRPM})]$$

$$\text{SW} = \left(\frac{\text{CF}}{0.6}\right) 39.42\,Q\,[\text{UNCPM} - \text{CTRPM}]$$

---

[a] SCA (ft^2/1000 acfm) = specific collection area = 400 ft^2/1000 acfm.

[b] TPA (ft^2) = total plate area = SCA * FLW/1000.

TABLE A-15.. COST EQUATIONS FOR FABRIC FILTERS APPLIED TO COAL-FIRED BOILERS

($30\text{-}700 \times 10^6$ Btu/hr) [2]

Routine Code: FF

Capital Costs:

$$\text{EQUP} = 8.340\ (\text{FLW})^{0.966}$$

$$\text{INST} = -1{,}506{,}523 + 168{,}531 \ln (\text{FLW})$$

$$\text{IND} = 24.990\ (\text{FLW})^{0.821}$$

Annual Costs:

$$\text{DL} = \text{LF}\ (10{,}150 + 106\ Q) \qquad \text{if } 30 \le Q \le 400$$

$$\text{LF}\ (52{,}600) \qquad \text{if } 400 < Q \le 700$$

$$\text{SPRV} = 0 \qquad \text{if } 30 \le Q \le 400$$

$$= \text{LF}\ (17{,}000) \qquad \text{if } 400 < Q \le 700$$

$$\text{MANT} = \text{LF}\ (14{,}840 + 0.106\ Q^2) \qquad \text{if } 30 \le Q \le 400$$

$$= \text{LF}\ (32{,}000) \qquad \text{if } 400 < Q \le 700$$

$$\text{SP} = 0.278\ (\text{FLW})^{0.997}$$

$$\text{UC} = \left(\frac{\text{CF}}{0.60}\right) 0.740\ (\text{FLW})^{0.953}$$

$$\text{SW} = \left(\frac{\text{CF}}{0.60}\right) 39.42\ Q\ (\text{UNCPM} - \text{CTRPM})$$

TABLE A-16. COST EQUATIONS FOR SINGLE MECHANICAL (MULTI-CYCLONE) COLLECTORS APPLIED TO COAL-FIRED BOILERS

$(30\text{-}700 \times 10^6$ Btu/hr$)^3$

Routine Code: SM

Capital Costs:

$TD = 32.53\ (FLW)^{0.7518}$

$IND = TD/3$

Annual Costs:

$DL = LF(5075 + 53\ Q)$

$SPRV = DL(0.15)$

$MANT = LF(7420 + 0.053(Q^2))$

$SP = 0.005(EQUIP + IND)$

$ELEC = 0.286\ (FLW) * CF$

$SW = (\frac{CF}{0.6})\ 39.42\ Q\ (UNCPM - CTRPM)$

TABLE A-17. COST EQUATIONS FOR DUAL MECHANICAL (MULTI-CYCLONE) COLLECTORS APPLIED TO COAL-FIRED BOILERS

($30\text{-}700 \times 10^6$ Btu/hr)[3]

Routine Code: DM

Capital Costs:

$TD = 24.54\ (FLW)^{0.813}$

$IND = TD/3.0$

Annual Costs:

$DL = LF\ (5075 + 53\ Q)$

$SPRV = (DL)\ 0.15$

$MANT = LF\ (7420 + 0.053\ Q^2)$

$SP = 0.005\ (EQUIP + IND)$

$ELEC = 0.3818\ (FLW)\ {*}CF$

$SW = \left(\frac{CF}{0.6}\right) 39.42\ Q\ (UNCPM - CTRPM)$

TABLE A-18. COST EQUATIONS FOR SIDE-STREAM SEPARATORS APPLIED TO COAL-FIRED BOILERS ($30\text{-}700 \times 10^6$ Btu/hr)[3]

Routine Code: SSS

Capital Costs:

$TD = 41.3\ (FLW)^{0.7869}$

$IND = TD/3.0$

Annual Costs:

$DL = LF(7105 + 74.2\ Q)$

$SPRV = (DL)\ 0.15$

$MANT = LF\ (10390 + 0.074(Q^2)) + 0.0554\ (FLW)^{0.997}$

$SP = 0.005\ (EQUIP + IND)$

$ELEC = 0.286\ (FLW) * CF + [\frac{CF}{0.6}]\ 0.160\ (FLW)^{0.953}$

$SW = (\frac{CF}{0.6})\ 39.42\ Q\ (UNCPM - CTRPM)$

TABLE A-19. COST EQUATIONS[5] FOR DUAL ALKALI FGD SYSTEMS WITHOUT PM REMOVAL[a]

Routine Code: DA

Capital Costs:[b,c]

$TDI = 45{,}200\ (FLW)^{0.61} + 83{,}118\ (S2)^{0.39}$

$TK = 1.48\ TDI + 93{,}600$ if $Q \leq 58.6$

$\quad\ = 1.48\ TDI + 130{,}000$ if $Q > 58.6$

Annual Costs:[b,c]

$DL = 105{,}000$

$SPRV = 21{,}000$

$MANT = 0.08\ TDI$

$ELEC = 8{,}760\ CF * ELECR\ [2.94\ FLW\ (0.121\ S1 + 0.861)]$

$WTR = 8{,}760\ CF * WTRR\ [0.197\ FLW + 0.30] *$

$\quad [0.977 + 0.119\ \ln S1]$

$SW = 8{,}760\ CF * SWDR\ [7.73\ S2 - 3.34]$

$SC = 8{,}760\ CF * SASHR\ [1.13\ FLW - 2.06] *$

$\quad [0.41 - 0.70\ (0.24 - S1)]^{1.74}$ if $S1 < 0.24$

$\quad 8{,}760\ CF * SASHR\ [1.13\ FLW - 2.06] *$

$\quad [0.70\ (S1 - 0.24)^{1.74} + 0.41]$ if $S1 \geq 0.24$

$LIME = 8{,}760\ CF * ALIMER\ [1.61\ S2 - 0.85]$

---

[a] FGD algorithms use metric units as noted in Table A-2.

[b] $S1 = S * EFFSO2 * 100/H$

[c] $S2 = S1 * Q/3.6$

TABLE A-20. COST EQUATIONS[5] FOR DUAL ALKALI FGD SYSTEMS WITH PM REMOVAL[a]

Routine Code: DAC

Capital Costs:[b,d]

$$\begin{aligned} \text{TDI} &= 74370 + 9.02 \times 10^3\,(\text{FLW}) - 39.5\,(\text{FLW})^2 + \\ &\quad 13{,}340\,(\text{FLW})^{0.528} + 32.32 \times 10^3\,(\text{S2})^{0.362} + \\ &\quad 54.06 \times 10^3\,[7.73\,\text{S2} - 3.34 + \text{P}]^{0.278} + \\ &\quad 4{,}094\,\text{FLW}^{0.834} \end{aligned}$$

$$\begin{aligned} \text{TK} &= 1.48\,\text{TDI} + 93{,}600 && \text{if } Q \le 58.6 \\ &= 1.48\,\text{TDI} + 130{,}000 && \text{if } Q > 58.6 \end{aligned}$$

Annual Costs:[b,c,d]

$$\text{DL} = 105{,}000$$

$$\text{SPRV} = 21{,}000$$

$$\text{MANT} = 0.08\,\text{TDI}$$

$$\begin{aligned} \text{ELEC} &= 8{,}760\,\text{CF} * \text{ELECR}\,(6.11\,\text{FLW}) * \\ &\quad [0.121\,\text{S1} + 0.861] \end{aligned}$$

$$\begin{aligned} \text{WTR} &= 8{,}760\,\text{CF} * \text{WTRR}\,[0.197\,(\text{FLW}) + 0.30] * \\ &\quad [0.977 + 0.119\,\ln \text{S1}] \end{aligned}$$

$$\text{SW} = 8{,}760\,\text{CF} * \text{SWDR}\,[7.73\,\text{S2} - 3.34 + \text{P}]$$

$$\begin{aligned} \text{SC} &= 8{,}760\,\text{CF} * \text{SASHR}\,[1.13\,\text{FLW} - 2.06] * \\ &\quad [0.41 - 0.70\,(0.24 - \text{S1})]^{1.74} && \text{if S1} < 0.24 \\ &= 8{,}760\,\text{CF} * \text{SASHR}\,[1.13\,(\text{FLW}) - 2.06] * \\ &\quad [0.70\,(\text{S1} - 0.24)^{1.74} + 0.41] && \text{if S1} \ge 0.24 \end{aligned}$$

$$\text{LIME} = 8{,}760\,\text{CF} * \text{ALIMER}\,[1.61\,\text{S2} - 0.85]$$

---

[a] FGD algorithms use metric units as noted in Table A-2.

[b] $P = 3.6 \times 10^{-3}\,Q\,(1.2\,\text{UNCPM} - 2\,\text{CTRPM})$

[c] $\text{S1} = \text{S} * \text{EFFSO2} * 100/\text{H}$

[d] $\text{S2} = \text{S1} * Q/3.6$

TABLE A-21. COST EQUATIONS[4] FOR SODIUM THROWAWAY FGD SYSTEMS[a]

Routine Code: NATH

Capital Costs:[b]

$\text{TDI} = 44{,}000\ (\text{FLW})^{0.62} + 20{,}600\ (\text{S1})^{0.427}$

$\text{TK} = 1.48\ \text{TDI} + 74{,}400$ if $Q \leq 58.6$

$= 1.48\ \text{TDI} + 112{,}800$ if $Q > 58.6$

Annual Costs:[b,c]

$\text{DL} = 105{,}000$

$\text{SPRV} = 21{,}000$

$\text{MANT} = 0.08\ \text{TDI}$

$\text{ELEC} = 8{,}760\ \text{CF ELECR}\ [4.26\ (\text{FLW}) - 2.56]\ [0.65 + 0.31\ \text{S1}]$

$\text{WTR} = 8{,}760\ \text{CF WTRR}\ [0.776\ (\text{FLW}) - 0.720]\ [0.213 + 0.684\ \text{S1}]$

$\text{SW} = 8{,}760\ \text{CF SWDR}\ [0.16 + 4.53\ \text{S2}]$

$\text{SC} = 8{,}760\ \text{CF SASHR}\ [8.03 + 3.5\ \text{S2}]$

$\text{LW} = 8{,}760\ \text{CF LWDR}\ (0.0860\ \text{S2})$

---

[a] FGD algorithms use metric units as noted in Table A-2.

[b] $\text{S1} = \text{S} * \text{EFFSO2} * 100/\text{H}$

[c] $\text{S2} = \text{S1} * \text{Q}/3.6$

TABLE A-22. COST EQUATIONS[5] FOR LIME SPRAY DRYING FGD SYSTEMS WITH PM REMOVAL[a]

Routine Code: DS

Capital Costs:[c]

$\mathrm{TDI} = 55{,}600\ (\mathrm{FLW})^{0.51} + 21{,}600\ (\mathrm{S2})^{0.40} + 33{,}327\ (\mathrm{FLW})^{0.89}$

$\mathrm{TK} = 1.48\ \mathrm{TDI} + 110{,}400$ if $Q \leq 58.6$
$\phantom{\mathrm{TK} = } 1.60\ \mathrm{TDI}$ if $Q > 58.6$

Annual Costs:[b,c]

$\mathrm{DL} = 105{,}000$

$\mathrm{SPRV} = 21{,}000$

$\mathrm{MANT} = 0.08\ [55{,}600\ (\mathrm{FLW})^{0.51} + 21{,}600\ (\mathrm{S2})^{0.40}] + 14{,}840 + 1.23\ Q^2 + 578\ (\mathrm{FLW})^{0.997}$

$\mathrm{ELEC} = 8{,}760\ \mathrm{CF} * \mathrm{ELECR}\ [6.14\ (\mathrm{FLW})^{0.82}]$

$\mathrm{WTR} = 8{,}760\ \mathrm{CF} * \mathrm{WTRR}\ [0.144\ (\mathrm{FLW})]$

$\mathrm{SW} = 8{,}760\ \mathrm{CF} * \mathrm{SWDR}\ [(0.035 * \mathrm{EFFSO2} + 3.02)\ (\mathrm{S2}) + \mathrm{UNCPM} * \mathrm{EFFPM}/100]$

$\mathrm{LIME} = 8{,}760\ \mathrm{CF} * \mathrm{ALIMER}\ (1.88\ \ln(\mathrm{EFFSO2}) - 5.3)\ \mathrm{S2}$

---

[a] FGD costs use metric units as noted in Table A-2.

[b] $\mathrm{S1} = \mathrm{S1} * \mathrm{EFFSO2} * 100/H$

[c] $\mathrm{S2} = \mathrm{S1} * Q/3.6$

TABLE A-23. FLUE GAS FLOWRATE ALGORITHMS[a,b]

Natural Gas	
$FLW = 8.14 \times 10^{6}\ Q/H$	(non-LEA)
$FLW = 6.81 \times 10^{6}\ Q/H$	(LEA)
Distillate and/or Residual	
$FLW = 0.189\ Q\ H^{0.77}$	(non-LEA)
$FLW = 0.156\ Q\ H^{0.77}$	(LEA)
Coal (Stoker)	
$FLW = EXP\ [8.14 \times 10^{-5} H] * 1.84 \times 10^{6}\ Q/H$	(non-LEA)
$FLW = EXP\ [8.14 \times 10^{-5} H] * 1.66 \times 10^{6}\ Q/H$	(LEA)
Coal (Pulverized)	
$FLW = 1.62 \times 10^{6} * EXP\ [8.03 \times 10^{-5}\ H] * Q/H$	(LEA)

---

[a] LEA and Non-LEA conditions are defined as follows:

NG and oil: LEA - 15% excess air
Non-LEA - 40% excess air

Coal: LEA - 35% excess air
Non-LEA - 50% excess air

[b] Reference 6.

TABLE A-24. COST EQUATIONS FOR LOW EXCESS AIR APPLIED TO INDUSTRIAL BOILERS[a]

Routine Code: LEA

Capital Costs:

Coal: $\text{EQUIP} = 46.22(Q) + 6496$
$\text{INST and IND} = 21.50(Q) + 1123$

Oil and Gas: $\text{EQUIP} = 31.38(Q) + 5185$
$\text{INST and IND} = 11.37(Q) + 1161$

Annual Costs:

SP[b] $= 0.05(\text{TK})$
$\text{FUEL} = -.00055(\text{FC})(Q)(\text{CF})(\text{FFAC})(\text{UNCEA} - \text{CTREA})$

---

[a] Algorithm assumes a flue gas temperature of 400°F and the ambient air temperature to be 77°F.

[b] Spare parts costs consist of the costs for spare parts, maintenance labor, and maintenance materials.

TABLE A-25. COST EQUATIONS FOR STAGED COMBUSTION AIR APPLIED TO PULVERIZED COAL-FIRED BOILERS

($>150 \times 10^6$ Btu/hr)

Routine Code: SCA

Capital Costs:

EQUIP = 65 (Q) + 13000
INST and IND = 60 (Q) + 2000

Annual Costs:

SP[a] = 0.05 (TK)
ELEC = 105 (Q)(CF)
FUEL = 21.9 (FC)(Q)(CF)

---

[a] Spare parts costs consist of the costs for spare parts, maintenance labor, and maintenance materials.

TABLE A-26. COST EQUATIONS FOR STAGED COMBUSTION AIR APPLIED TO RESIDUAL OIL-FIRED BOILERS[7] (Fuel N >0.23 wt. percent)

($30 - 250 \times 10^6$ Btu/hr)

Routine Code: SCA

Capital Costs:

$TK = 1000 [(Q)(PRCT)\ 0.0536 + 2.56\ (PRCT)]$

where:

$PRCT = 30$; when $N > 0.6$

$PRCT = 81.1(N) - 18.7$ when $0.23 < N < 0.6$

Annual Costs:

$SP^a = 0.05\ (TK)$

$ELEC = 102\ (Q)(CF)$

$FUEL = 21.9\ (FC)(Q)(CF)$

---

[a] Spare part costs consists of the costs for spare parts, maintenance labor, and maintenance materials.

TABLE A-27. COST EQUATIONS FOR FLUE GAS RECIRCULATION APPLIED TO OIL- AND GAS-FIRED BOILERS

$(<250 \times 10^6$ Btu/hr)

Routine Code: FGR

Capital Costs:

EQUIP = $44.72(Q) + 8383$
INST and IND = $35.6\ (Q) + 4189$

Annual Costs:

$SP^a = 0.05\ (TK)$
ELEC = $(243(Q) + 175)CF$
FUEL = $43.8\ (FC)(Q)(CF)$

---

[a] Spare parts costs consist of the costs for spare parts, maintenance labor, and maintenance materials.

TABLE A-28. COST EQUATIONS FOR REDUCED AIR PREHEAT APPLIED TO OIL- AND GAS-FIRED BOILERS[7]

Routine Code: RAP

Annual Costs:[a]

$$\text{FUEL} = 1.726 \times 10^{-4}\ (\text{Q})\ (\text{FC})\ (\text{CF})\ (\text{FFAC})\ (1 + \text{UNCEA}/100)\ \text{DELT}$$

---

[a] This algorithm predicts the incremental fuel cost associated with not recovering heat from the boiler flue gas.

APPENDIX A

REFERENCES

1. PEDCo Environmental, Inc. Cost Equations for Industrial Boilers. Final Report. (Prepared for U. S. Environmental Protection Agency.) Research Triangle Park, N. C. EPA Contract No. 68-02-3074. January 1980. 23 p.

2. PEDCo Environmental, Inc. Capital and Operating Costs of Particulate Controls on Coal- and Oil-Fired Industrial Boilers. (Prepared for U. S. Environmental Protection Agency.) Research Triangle Park, N. C. EPA-450/5-80-009. August 1980. 129 p.

3. Tighe, S. C., and M. S. Jennings. (Radian Corporation.) Mechanical Collectors for Particulate Control on Stoker Coal-Fired Boilers. January 13, 1981. 35 p.

4. Gardner, R., R. Chang, and L. Broz. (Acurex Corporation.) Cost, Energy and Environmental Algorithms for NO_x, SO_2, and PM Controls for Industrial Boilers. Final Report. (Prepared for U. S. Environmental Protection Agency.) Cincinnati, Ohio. EPA Contract No. 68-03-2567. December 1979. p. 20-52.

5. Memo from Kelly, M. E. (Radian Corporation.) to Industrial Boiler File. Summary of Radian Cost Algorithm Development for Industrial Boiler NSPS. January 21, 1981. 33 p.

6. Reference 4, p. 15-19.

7. Memo from Bowen, M.L., Radian Corporation, to Jones, L., EPA:SDB. July 28, 1982. 12 p. NO_x Combustion Modification Cost Algorithm Development.

APPENDIX B

LISTING OF FORTRAN COST ANALYSIS PROGRAM

A FORTRAN computer program was used to develop the costs presented in this report. This appendix provides a listing of the program. A comment block at the beginning of the program provides general information concerning its use.

A basic structure consists of a main subroutine (COST) which accesses various support subroutines. Each costing algorithm presented in Appendix A (Table A-1) is implemented in a separate subroutine. COST accesses these subroutines and provides input/output functions.

Because COST is written as a subroutine rather than a main program, a small main program must be written to use COST. The listing which follows includes such a main program.

```
DSNAME='XEXDUR.D0016.MSTR3.DATA'
//XEXDUR1 JOB (XEXDUR,VVPOD0016),'MLB',MSGCLASS=Q,NOTIFY=XEXDUR
//STEP1    EXEC FORTGCLG,CLASS=Q
//FORT.SYSIN DD *
      REAL CAPC(10,5),OMC(19,5),ANNC(5,5),ADATE(2)
      DATA BLANK,ADS,ADAC/'    ','DS  ','DAC '/
      READ (5,1000) NN,(ADATE(I),I=1,2)
 1000 FORMAT (I4,2A4)
      CALL CSTCRD
      DO 10 I=1,NN
      DO 20 J=1,5
      DO 30 K=1,10
   30 CAPC(K,J)=0.0
      DO 40 K=1,19
   40 OMC(K,J)=0.0
      DO 50 K=1,5
   50 ANNC(K,J)=0.0
   20 CONTINUE
      READ (5,1001) AB,ASO2,APM,IFFLAG
 1001 FORMAT (3A4,I4)
      WRITE (6,1003) I,(ADATE(J),J=1,2),AB,ASO2,APM,IFFLAG
 1003 FORMAT (////T2,'MODEL BOILER',I4,T45,2A4/T2,
     *          'BOILER ROUTINE ',A4,T25,'SO2 ROUTINE= ',A4,T50,
     *          'PM ROUTINE= ',A4,T75,'FLOW FLAG= ',I4/)
      CALL COST(I,AB,1,1,IFFLAG,CAPC(1,1),OMC(1,1),ANNC(1,1))
      IF (ASO2 .EQ. BLANK) GO TO 60
      CALL SO2CRD
      IF ((ASO2 .EQ. ADS) .OR. (ASO2 .EQ. ADAC)) CALL PMCRD
      CALL COST(I,ASO2,1,0,IFFLAG,CAPC(1,3),OMC(1,3),ANNC(1,3))
   60 CONTINUE
      IF (APM .EQ. BLANK) GO TO 70
      CALL PMCRD
      CALL COST(I,APM,1,0,IFFLAG,CAPC(1,4),OMC(1,4),ANNC(1,4))
   70 CONTINUE
      CALL BPRNT
      CALL FPRNT
      CALL PMPRNT
      CALL S2PRNT
      CALL CPRNT
      CALL CSTTBL(CAPC,OMC,ANNC,I)
   10 CONTINUE
      RETURN
      END
      SUBROUTINE COST (NN,ANAME,IPFLAG,IRFLAG,IFFLAG,CAPC,OMC,ANNC)
C
```

```
C ------------------------------------------------------------------------
C
C COST - COMPUTES CAPITAL, O AND M, AND ANNUAL COSTS OF BOILER
C        AND CONTROL SYSTEM(S)
C WRITTEN BY:  M.S. JENNINGS (7/81).  SUPPLEMENTARY DOCUMENTAION AVAILA
C TO USE, EXECUTE A STATEMENT OF THE FORM
C        CALL COST (NN,ANAME,IPFLAG,IRFLAG,IFFLAG,CAPC,OMC,ANNC)
C WHERE:
C        NN =      ID NUMBER (USER SUPPLIED) PRINTED TO OUTPUT (IF DESI
C                  FOR IDENTIFICATION OF ROUTINE
C        ANAME =   ROUTINE TO BE USED (USER SUPPLIED).  ANAME SHOULD BE
C                  'A' FORMAT (MAXIMUM OF FOUR CHARACTERS).  SEE USER M
C                  FOR DESCRIPTION OF VARIOUS ROUTINES AVAILABLE AND IN
C                  REQUIREMENTS FOR EACH.
C        IPFLAG = PRINT FLAG (USER SUPPLIED).
C                  0 INDICATES NO PRINTING
C                  1 INDICATES ONLY INTERMEDIATE CALCULATIONS PRINTED
C                  2 INDICATES INTERMEDIATE CALCULATIONS AND INPUT DATA
C                  3 INDICATES INTERMEDIATE CALCULATIONS, INPUT DATA,
C                    AND FINAL COST RESULTS PRINTED
C        IRFLAG =  READ FLAG (USER SUPPLIED) SET NON-ZERO IF INPUT DATA
C                  BE READ FROM INPUT DECK (SEE USERS MANUAL FOR CARD F
C                  REQUIRED FOR ROUTINE SPECIFIED IN ANAME).
C        IFFLAG =  FLUE GAS FLOWRATE FLAG (USER SUPPLIED) SET NONZERO I
C                  ROUTINE IS TO CALCULATE FLUE GAS FLOWRATE.  VALUES
C                  SHOULD BE SET AS FOLLOWS:
C                            0 = FLOWRATE USER SUPPLIED
C                            1 = COAL, MASS FEED, LEA CONDITIONS
C                            2 = COAL, MASS FEED, NON-LEA
C                            3 = PULVERIZED COAL, LEA CONDITIONS
C                            4 = NATURAL GAS, LEA CONDITIONS
C                            5 = NATURAL GAS NON-LEA
C                            6 = OIL, LEA CONDITIONS
C                            7 = OIL, NON-LEA
C        CAPC =    ARRAY OF CAPITAL COSTS (RETURNED).  COMPONENTS OF AR
C                  AS LISTED BELOW:
C                            CAPC(1) = EQUIPMENT
C                            CAPC(2) = INSTALLATION
C                            CAPC(3) = TOTAL DIRECT
C                            CAPC(4) = INDIRECT
C                            CAPC(5) = TOTAL DIRECT AND INDIRECT
C                            CAPC(6) = CONTINGENCIES
C                            CAPC(7) = TURNKEY
C                            CAPC(8) = LAND
C                            CAPC(9) = WORKING CAPITAL
```

```
00070000 C                      CAPC(10) = TOTAL CAPITAL
00071000 C       OMC =     ARRAY OF OPERATIONAL AND MAINTENANCE COSTS (RETURNED
00072000 C                 COMPONENTS OF ARRAY ARE AS LISTED BELOW:
00073000 C                           OMC(1) = DIRECT LABOR
00074000 C                           OMC(2) = SUPERVISION LABOR
00075000 C                           OMC(3) = MAINTENANCE LABOR
00076000 C                           OMC(4) = SPARE PARTS
00077000 C                           OMC(5) = ELECTRICITY
00078000 C                           OMC(6) = UTILITIES AND CHEMICALS
00079000 C                           OMC(7) = WATER
00080000 C                           OMC(8) = SOLID WASTE DISPOSAL
00081000 C                           OMC(9) =  SLUDGE WASTE DISPOSAL
00082000 C                           OMC(10) = LIQUID WASTE DISPOSAL
00083000 C                           OMC(11) = SODIUM CARBONATE
00084000 C                           OMC(12) = LIMESTONE
00085000 C                           OMC(13) = LIME
00086000 C                           OMC(14) = AMMONIA
00087000 C                           OMC(15) = SODIUM HYDROXIDE
00088000 C                           OMC(16) = FUEL
00089000 C                           OMC(17) = TOTAL DIRECT O AND M
00090000 C                           OMC(18) = OVERHEAD
00091000 C                           OMC(19) = TOTAL O AND M
00092000 C       ANNC =    ARRAY OF ANNUALIZED COSTS (RETURNED).  COMPONENTS
00093000 C                 ARE AS LISTED BELOW:
00094000 C                           ANNC(1) = CAPITAL RECOVERY
00095000 C                           ANNC(2) = WORKING CAPITAL CHARGES
00096000 C                           ANNC(3) = MISCELLANEOUS (G AND A, TAXES,
00097000 C                                      AND INSURANCE)
00098000 C                           ANNC(4) = TOTAL CAPITAL CHARGES
00099000 C                           ANNC(5) = TOTAL ANNUALIZED CHARGES
00100000 C FIVE COMMON BLOCKS ARE USED BY COST TO COMMUNICATE BETWEEN VARIOUS
00101000 C SUBROUTINES.  THESE ARE:
00102000 C       COMMON /BSPEC/ Q,FLW,CF,BCRF
00103000 C       COMMON /FUEL/ FC,H,S,A
00104000 C       COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
00105000 C       COMMON /SO2/ UNCSO2,CTRSO2,EFFSO2,CRFSO2
00106000 C       COMMON /COSTS/ DLR,SLR,AMLR,ELEC,WTR,ALIME,ALS,ALYE,SASH,SLDG,
00107000 C VARIABLE DEFINITIONS ARE AS FOLLOWS:
00108000 C       Q = BOILER THERMAL INPUT (MMBTU/HR)
00109000 C       FLW = BOILER FLUE GAS FLOWRATE (ACFM)
00110000 C       CF = BOILER CAPACITY FACTOR (-)
00111000 C       BCRF = BOILER CAPITAL RECOVERY FACTOR (-)
00112000 C       FC = FUEL COST (DOLLARS/MMBTU)
00113000 C       H = FUEL HEATING VALUE (BTU/LB)
00114000 C       S = SULFUR CONTENT (PERCENT BY WEIGHT)
```

```
C         A = ASH CONTENT (PERCENT BY WEIGHT)
C         UNCPM = UNCONTROLLED PM EMISSIONS (LB/MMBTU)
C         CTRPM = CONTROLLED PM EMISSIONS (LB/MMBTU)
C         EFFPM = PM REMOVAL EFFICIENCY (PERCENT)
C         CRFPM = CAPITAL RECOVERY FACTOR FOR PM CONTROL SYSTEM (-)
C         UNCSO2 = UNCONTROLLED SO2 EMISSIONS (LB/MMBTU)
C         CTRSO2 = CONTROLLED SO2 EMISSIONS(LB/MMBTU)
C         EFFSO2 = SO2 REMOVAL EFFICIENCY (PERCENT) (NOTE: IF SUBROUTINE
C                   READS DATA THIS VALUE IS CALCULATED INTERNALLY AND
C                   DOES NOT NEED TO BE PROVIDED).
C         CRFSO2 = CAPITAL RECOVERY FACTOR FOR SO2 CONTROL SYSTEM (-)
C         DLR = DIRECT LABOR RATE (DOLLARS/MAN-HR)
C         SLR = SUPERVISION LABOR RATE (DOLLARS/MAN-HR)
C         AMLR = MAINTENANCE LABOR RATE (DOLLARS/MAN-HR)
C         ELEC = ELECTRICITY RATE (DOLLARS/KW-HR)
C         WTR = WATER RATE (DOLLARS/1000 GALS)
C         ALIME = LIME RATE (DOLLARS/TON)
C         ALS = LIMESTONE RATE (DOLLARS/TON)
C         ALYE =    LYE RATE (DOLLARS/1000 GALS)
C         SASH = SODA ASH RATE (DOLLARS/TON)
C         SLDG = SLUDGE DISPOSAL RATE (DOLLARS/TON)
C         SWD = SOLID WASTE DISPOSAL RATE (DOLLARS/TON)
C         ALWD = LIQUID WASTE DISPOSAL RATE (DOLLARS/1000 GALS)
C  NOTE:  SOME OF THE COSTS PRESENTED ABOVE ARE NOT USED IN THE ROUTINES
C         EXAMPLE, THE BOILER COSTING ROUTINES ASSUME CONSTANTS FOR MANY
C         OF THE ABOVE COST RATES AND CHANGING THE VALUES ABOVE WILL HAV
C         EFFECT ON THE FINAL COSTS GENERATED (SEE USERS MANAUAL).
C
C ---------------------------------------------------------------------
C
      REAL CAPC(10),OMC(19),ANNC(5)
      REAL AA(19)
      DATA AA /'UNDR','SPRD','PLVR','DNG1','DNG2','RES1','RNG1','RNG2',
     *         'ESPC','ESPO','FF','VS','SM','DM','SSS','DA','NATH',
     *         'DAC','DS'/
C
C
C  ZERO COST ARRAYS
      DO 10 I=1,10
 10   CAPC(I) = -0.0
      DO 20 I=1,19
 20   OMC(I) = -0.0
      DO 30 I=1,5
 30   ANNC(I) = -0.0
C  CHECK FOR INPUT ON INPUT DECK
```

```
      IF (IRFLAG.NE.0) CALL READER (ANAME)
C  CHECK FOR FLUE  GAS FLOWRATE CALCULATIONS
      IF (IFFLAG.NE.0) CALL FLUE(IFFLAG)
C  CHECK FOR PRINTING DESIRED
      IF (IPFLAG.GE.2) CALL IPRNT(ANAME)
C  CALL APPROPRIATE ROUTINE TO COMPUTE COSTS
      IF (ANAME.EQ.AA(1))  CALL UNDR(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(2))  CALL SPRD(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(3))  CALL PLVR(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(4))  CALL DNG1(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(5))  CALL DNG2(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(6))  CALL RES1(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(7))  CALL RNG1(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(8))  CALL RNG2(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(9))  CALL ESPC(CAPC,OMC,ANNC,IPFLAG)
      IF (ANAME.EQ.AA(10))  CALL ESPO(CAPC,OMC,ANNC,IPFLAG)
      IF (ANAME.EQ.AA(11))  CALL FF(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(12))  CALL VS(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(13))  CALL SM(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(14))  CALL DM(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(15))  CALL SSS(CAPC,OMC,ANNC)
      IF (ANAME.EQ.AA(16))  CALL DA(CAPC,OMC,ANNC,IPFLAG)
      IF (ANAME.EQ.AA(17))  CALL NATH(CAPC,OMC,ANNC,IPFLAG)
      IF (ANAME.EQ.AA(18))  CALL DAC(CAPC,OMC,ANNC,IPFLAG)
      IF (ANAME.EQ.AA(19))  CALL DS(CAPC,OMC,ANNC,IPFLAG)
C
C  IF ASKED, PRINT RESULTS
      IF (IPFLAG.EQ.3) CALL SPILL (NN,ANAME,CAPC,OMC,ANNC)
C
C
      RETURN
      END
      SUBROUTINE READER (ANAME)
C  READER - READS INPUT DECK FOR NAMED ROUTINE
C  INPUT  - ANAME = ALPHA VARIABLE GIVING NAME OF ROUTINE FOR WHICH
C                   INPUT IS DESIRED
C  OUTPUT - COMMON BLOCKS BSPEC,SO2,PM,AND COSTS ARE FILLED AS APPROPRIA
C
      REAL AA(19)
      DATA AA /'UNDR','SPRD','PLVR','DNG1','DNG2','RES1','RNG1','RNG2',
     *         'ESPC','ESPO','FF','VS','SM','DM','SSS','DA','NATH',
     *         'DAC','DS'/
C  SEARCH FOR ROUTINE
      IF (ANAME.EQ.AA(1)) GO TO 10
      IF (ANAME.EQ.AA(2)) GO TO 10
      IF (ANAME.EQ.AA(3)) GO TO 10
      IF (ANAME.EQ.AA(4)) GO TO 10
      IF (ANAME.EQ.AA(5)) GO TO 10
      IF (ANAME.EQ.AA(6)) GO TO 10
      IF (ANAME.EQ.AA(7)) GO TO 10
      IF (ANAME.EQ.AA(8)) GO TO 10
      IF (ANAME.EQ.AA(9)) GO TO 20
      IF (ANAME.EQ.AA(10)) GO TO 20
      IF (ANAME.EQ.AA(11)) GO TO 20
      IF (ANAME.EQ.AA(12)) GO TO 20
      IF (ANAME.EQ.AA(13)) GO TO 20
      IF (ANAME.EQ.AA(14)) GO TO 20
      IF (ANAME.EQ.AA(15)) GO TO 20
      IF (ANAME.EQ.AA(16)) GO TO 30
      IF (ANAME.EQ.AA(17)) GO TO 30
      IF (ANAME.EQ.AA(18)) GO TO 40
      IF (ANAME.EQ.AA(19)) GO TO 40
C  IF ROUTINE CANT BE LOCATED, OUTPUT MESSAGE AND STOP
      WRITE (6,1000) ANAME
 1000 FORMAT (/T2,'ROUTINE ',A4,' NOT RECOGNIZED - PROGRAM ABORTED')
      STOP
C  BOILER ROUTINE TO BE CALLED .
 10   CALL BCRD
      CALL FCRD
      RETURN
C  PM ROUTINE TO BE CALLED
 20   CALL BCRD
      CALL FCRD
      CALL PMCRD
      RETURN
C  SO2 ROUTINE TO BE CALLED
 30   CALL BCRD
      CALL FCRD
      CALL SO2CRD
      CALL CSTCRD
      RETURN
C  COMBINED SO2 AND PM ROUTINE TO BE CALLED
 40   CALL BCRD
      CALL FCRD
      CALL SO2CRD
      CALL PMCRD
      CALL CSTCRD
      RETURN
      END
      SUBROUTINE BCRD
```

```
C  BCRD - READS IN A BOILER CARD
C
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      READ (5,1000) Q,FLW,CF,BCRF
 1000 FORMAT (8F10.0)
      RETURN
      END
      SUBROUTINE FCRD
C  FCRD - READS IN A FUEL CARD
C
      COMMON /FUEL/ FC,H,S,A
      READ (5,1000) FC,H,S,A
 1000 FORMAT (8F10.0)
      RETURN
      END
      SUBROUTINE PMCRD
C  PMCRD - READS IN A PM CARD
C
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      READ (5,1000) UNCPM,CTRPM,EFFPM,CRFPM
 1000 FORMAT (8F10.0)
      RETURN
      END
      SUBROUTINE SO2CRD
C  SO2CRD - READS IN A SO2 CARD
C
      COMMON /SO2/ UNCSO2,CTRSO2,EFFSO2,CRFSO2
      READ (5,1000) UNCSO2,CTRSO2,EFFSO2,CRFSO2
 1000 FORMAT (8F10.0)
      RETURN
      END
      SUBROUTINE CSTCRD
C  CSTCRD - READS IN A COST RATE CARD
C
      COMMON /COSTS/ DLR,SLR,AMLR,ELEC,WTR,ALIME,ALS,ALYE,SASH,SLDG,
     *               SWD,ALWD
      READ (5,1000) ELEC,WTR,ALIME,ALS,SASH,SLDG,SWD,ALWD
 1000 FORMAT (8F9.0)
      RETURN
      END
      SUBROUTINE FLUE (IFFLAG)
C  FLUE - CALCULATES FLUE GAS FLOWRATES
C
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      IF (IFFLAG.EQ.1) FLW=1.66E6*Q*EXP(8.141E-5*H)/H
      IF (IFFLAG.EQ.2) FLW=1.836E6*Q*EXP(8.141E-5*H)/H
      IF (IFFLAG.EQ.3) FLW=1.617E6*Q*EXP(8.025E-5*H)/H
      IF (IFFLAG.EQ.4) FLW=6.805E6*Q/H
      IF (IFFLAG.EQ.5) FLW=8.1398E6*Q/H
      IF (IFFLAG.EQ.6) FLW=0.1555*Q*H**0.77
      IF (IFFLAG.EQ.7) FLW=0.1887*Q*H**0.77
      RETURN
      END
      SUBROUTINE IPRNT(ANAME)
C  IPRNT - PRINTS OUT INPUT DATA
C  INPUT -
C         ANAME =   NAME OF ROUTINE TO BE USED IN COST ESTIMATION
C
      REAL AA(19)
      DATA AA /'UNDR','SPRD','PLVR','DNG1','DNG2','RES1','RNG1','RNG2',
     *         'ESPC','ESPO','FF','VS','SM','DM','SSS','DA','NATH',
     *         'DAC','DS'/
C  SEARCH FOR ROUTINE
      IF (ANAME.EQ.AA(1)) GO TO 10
      IF (ANAME.EQ.AA(2)) GO TO 10
      IF (ANAME.EQ.AA(3)) GO TO 10
      IF (ANAME.EQ.AA(4)) GO TO 10
      IF (ANAME.EQ.AA(5)) GO TO 10
      IF (ANAME.EQ.AA(6)) GO TO 10
      IF (ANAME.EQ.AA(7)) GO TO 10
      IF (ANAME.EQ.AA(8)) GO TO 10
      IF (ANAME.EQ.AA(9)) GO TO 20
      IF (ANAME.EQ.AA(10)) GO TO 20
      IF (ANAME.EQ.AA(11)) GO TO 20
      IF (ANAME.EQ.AA(12)) GO TO 20
      IF (ANAME.EQ.AA(13)) GO TO 20
      IF (ANAME.EQ.AA(14)) GO TO 20
      IF (ANAME.EQ.AA(15)) GO TO 20
      IF (ANAME.EQ.AA(16)) GO TO 30
      IF (ANAME.EQ.AA(17)) GO TO 30
      IF (ANAME.EQ.AA(18)) GO TO 40
      IF (ANAME.EQ.AA(19)) GO TO 40
C  IF ROUTINE CANT BE LOCATED, OUTPUT MESSAGE AND STOP
      WRITE (6,1000) ANAME
 1000 FORMAT (/T2,'ROUTINE ',A4,' NOT RECOGNIZED - PROGRAM ABORTED')
      STOP
C   BOILER ROUTINE TO BE RUN
 10   CALL BPRNT
      CALL FPRNT
      RETURN
C  PM ROUTINE TO BE RUN
 20   CALL BPRNT
      CALL FPRNT
      CALL PMPRNT
      RETURN
C  SO2 ROUTINE TO BE RUN
 30   CALL BPRNT
      CALL FPRNT
      CALL S2PRNT
      CALL CPRNT
      RETURN
C  COMBINED SO2 AND PM ROUTINE TO BE RUN
 40   CALL BPRNT
      CALL FPRNT
      CALL S2PRNT
      CALL PMPRNT
      CALL CPRNT
      RETURN
      END
      SUBROUTINE BPRNT
C  BPRNT - PRINTS OUT BOILER  SPECIFICATIONS
C
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      WRITE (6,1000) Q,FLW,CF,BCRF
 1000 FORMAT (T2,'BOILER SPECIFICATIONS'/
     *        T5,'Q=',T11,F6.1,T18,
     *        'FLW=',T23,F6.0,T30,
     *        'CF=',T35,F6.3,T42,
     *        'CRF=',T47,F6.4)
      RETURN
      END
      SUBROUTINE FPRNT
C  FPRNT - PRINTS OUT FUEL SPECIFICATIONS
C
      COMMON /FUEL/ FC,H,S,A
      WRITE (6,1000) FC,H,S,A
 1000 FORMAT (T2,'FUEL SPECIFICATIONS'/
     *        T5,'FC=',T11,F6.2,T18,
     *        'H=',T23,F6.0,T30,
     *        'S=',T35,F6.2,T42,
     *        'A=',T47,F6.2)
      RETURN
      END
      SUBROUTINE PMPRNT
```

```
C  PMPRNT - PRINTS OUT PM EMISSIONS DATA
C
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      WRITE (6,1000) UNCPM,CTRPM,EFFPM,CRFPM
 1000 FORMAT (T2,'PM EMISSIONS'/
     *        T5,'UNC=',T11,F6.3,T18,
     *        'CTR=',T23,F6.3,T30,
     *        'EFF=',T35,F6.2,T42,
     *        'CRF=',T47,F6.4)
      RETURN
      END
      SUBROUTINE S2PRNT
C  S2PRNT - PRINTS OUT SO2 EMISSIONS DATA
C
      COMMON /SO2/ UNCSO2,CTRSO2,EFFSO2,CRFSO2
      WRITE (6,1000) UNCSO2,CTRSO2,EFFSO2,CRFSO2
 1000 FORMAT (T2,'SO2 EMISSIONS'/
     *        T5,'UNC=',T11,F6.3,T18,
     *        'CTR=',T23,F6.3,T30,
     *        'EFF=',T35,F6.2,T42,
     *        'CRF=',T47,F6.4)
      RETURN
      END
      SUBROUTINE CPRNT
C  CPRNT - PRINTS OUT COST RATE DATA
C
      COMMON /COSTS/ DLR,SLR,AMLR,ELEC,WTR,ALIME,ALS,ALYE,SASH,SLDG,
     *               SWD,ALWD
      WRITE (6,1000) ELEC,WTR,ALIME,ALS,SASH,SLDG,SWD,ALWD
 1000 FORMAT (T2,'COST RATES'/
     *        T5,'ELEC=',T11,F6.4,T18,
     *        'WTR=',T23,F6.2,T30,
     *        'LIME=',T35,F6.2,T42,
     *        'ALS=',T47,F6.2,T54,
     *        'SASH=',T59,F6.2,T66,
     *        'SLDG=',T71,F6.2,T78,
     *        'SWD=',T83,F6.2,T90,
     *        'ALWD=',T95,F6.2)
      RETURN
      END
      SUBROUTINE CSTTBL(CAPC,OMC,ANNC,N)
C  CSTTBL - PRINTS OUT A BOILER COST TABLE
C  INPUT -
C         CAPC =    10 X 5 ARRAY OF CAPITAL COSTS
C         OMC =     19 X 5 ARRAY OF O AND M COSTS
```

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C         ANNC =    5 X 5 ARRAY OF TOTAL ANNUALIZED COSTS
C         NOTE:     IN THESE THREE ARRAYS, THE FIRST SUBSCRIPT DENOTES
C                   THE COST COMPONENT.  THE SECOND SUBSCRIPT DENOTES
C                   THE BOILER OR CONTROL SYSTEM AS FOLLOWS:
C                             1 =       BOILER
C                             2 =       NOX CONTROL
C                             3 =       SO2 CONTROL
C                             4 =       PM CONTROL
C                             5 =       TOTAL (SUM OF 1 - 4)
C         N =       IDENTIFICATION NUMBER PRINTED TO OUTPUT
C
C  CSTTBL AUTOMATICALLY PERFORMS THE SUMMING OF COSTS INTO THE FIFTH
C         COLUMN OF EACH COST ARRAY
C
      REAL CAPC(10,5),OMC(19,5),ANNC(5,5),ACAPC(10),AOMC(19),AANNC(5)
      DATA ACAPC /'EQUP','INST','TD','IND','TDI','CONT','TK','LAND',
     *            'WC','TOTL'/,
     *     AOMC /'DL','SPRV','MANT','SP','ELEC','UC','WTR','SW',
     *             'SLDG','LW','SC','LMS','LIME','NH3','LYE','FUEL',
     *             'TDOM','OH','TOTL'/,
     *     AANNC /'CR','WCC','MISC','TCC','TOTL'/
      DO 100 J=1,4
      DO 200 K=1,10
  200 CAPC(K,5)=CAPC(K,5)+CAPC(K,J)
      DO 210 K=1,19
  210 OMC(K,5)=OMC(K,5)+OMC(K,J)
      DO 220 K=1,5
  220 ANNC(K,5)=ANNC(K,5)+ANNC(K,J)
  100 CONTINUE
      WRITE (6,1000) N
 1000 FORMAT (/T2,'COST SUMMARY TABLE - RUN NO. ',I5/T2,80('-')/
     *        T2,'ITEM',T15,
     *        'BOILER',T30,'NOX CONTROL',T45,'SO2 CONTROL',T60,
     *        'PM CONTROL',T75,'TOTAL'/T2,80('-')/)
      DO 10 I=1,10
   10 WRITE (6,1001) ACAPC(I), (CAPC(I,J),J=1,5)
 1001 FORMAT (T2,A4,T10,5(F12.0,3X))
      WRITE (6,1002)
 1002 FORMAT (' ')
      DO 20 I=1,19
  20  WRITE (6,1001) AOMC(I),(OMC(I,J),J=1,5)
      WRITE (6,1002)
      DO 30 I=1,5
  30  WRITE (6,1001) AANNC(I),(ANNC(I,J),J=1,5)
      RETURN
      END
      SUBROUTINE SPILL (N,ANAME,CAPC,OMC,ANNC)
C  SPILL - OUTPUTS A DETAILED COST BREAKDOWN
C  INPUT - CAPC = ARRAY OF CAPITAL COSTS
C          OMC = ARRAY OF OPERATION AND MAINTENANCE COSTS
C          ANNC = ARRAY OF ANNUALIZED COSTS
C  OUTPUT - COSTS ARE PRINTED
C
      REAL CAPC(10),OMC(19),ANNC(5)
      REAL ACAPC(10),AOMC(19),AANNC(5)
      DATA ACAPC /'EQUP','INST','TD','IND','TDI','CONT','TK','LAND',
     *            'WC','TOTL'/,
     *    AOMC /'DL','SPRV','MANT','SP','ELEC','UC','WTR','SW',
     *              'SLDG','LW','SC','LMS','LIME','NH3','LYE','FUEL',
     *              'TDOM','OH','TOTL'/,
     *    AANNC /'CR','WCC','MISC','TCC','TOTL'/
C  WRITE OUT HEADER
      WRITE (6,1000) ANAME,N
 1000 FORMAT (/T2,'COST BREAKDOWN - ROUTINE ',A4,' - RUN NO. ',I5)
C  OUTPUT CAPITAL COSTS
      WRITE (6,1001)
 1001 FORMAT (T2,'CAPITAL COSTS')
      DO 10 I=1,10
 10   IF (CAPC(I).NE.0.0) WRITE (6,1002) ACAPC(I),CAPC(I)
 1002 FORMAT (T2,A4,' = ',F12.1)
C  OUTPUT O AND M COSTS
      WRITE (6,1003)
 1003 FORMAT (T2,'OPERATION AND MAINTENANCE COSTS')
      DO 30 I=1,19
 30   IF (OMC(I).NE.0.0) WRITE (6,1002) AOMC(I),OMC(I)
C  OUTPUT ANNUALIZED COSTS
      WRITE (6,1004)
 1004 FORMAT (T2,'ANNUALIZED COSTS')
      DO 50 I=1,5
 50   IF (ANNC(I).NE.0.0) WRITE (6,1002) AANNC(I),ANNC(I)
      RETURN
      END
      SUBROUTINE FNLCST(CAPC,OMC,ANNC,CRF,IFLAG)
C  FNLCST - PERFORMS FINAL COST CALCULATIONS FOR COMMON OPERATIONS
C
      REAL CAPC(10),OMC(19),ANNC(5)
      DATA OH1,OH2,WCF1,WCF2,WCF3,GA,CTG
     $    /0.56,0.26,0.25,0.10,0.0833,0.04,0.2/
      IF (IFLAG .EQ. 0) GO TO 20
      CAPC(3)=CAPC(1)+CAPC(2)
      CAPC(5)=CAPC(3)+CAPC(4)
      CAPC(6)=CTG*CAPC(5)
      CAPC(7)=CAPC(6)+CAPC(5)
      DO 10 I=1,16
   10 OMC(17)=OMC(17)+OMC(I)
      OMC(18)=OH1*OMC(1)+OH2*(OMC(2) + OMC(3) + OMC(4))
      OMC(19)=OMC(17) + OMC(18)
      CAPC(9)=WCF1*(OMC(17)-OMC(16))+WCF3*OMC(16)
      CAPC(10)=CAPC(7)+CAPC(8)+CAPC(9)
   20 ANNC(1)=CRF*CAPC(7)
      ANNC(2)=WCF2*CAPC(9)
      ANNC(3)=GA*CAPC(7)
      ANNC(4)=ANNC(1)+ANNC(2)+ANNC(3)
      ANNC(5)=ANNC(4)+OMC(19)
      RETURN
      END
      REAL FUNCTION ALF(CF)
C  ALF - FUNCTION TO CALCULATE LABOR FACTORS BASED ON CAPACITY FACTORS
C
      IF(CF .GT. 0.7) ALF=1.0
      IF ((CF .LE. 0.7) .AND. (CF .GE. 0.5)) ALF=0.5+2.5*(CF-0.5)
      IF (CF .LT. 0.5) ALF=0.5
      RETURN
      END
      SUBROUTINE LIMIT (Q,QLOW,QHIGH,ANAME)
C  LIMIT - CHECKS TO SEE IF THERMAL INPUT WITHIN BOUNDS OF ALGORITHM
C  INPUT - Q = THERMAL INPUT
C             QLOW =LOWER LIMIT
C             QHIGH = UPPER LIMIT
C             ANAME = ALPHA STRING OF ROUTINE CALLED
C
C  CHECK LIMITS
      IF ((Q .LT. QLOW) .OR. (Q .GT. QHIGH)) WRITE (6,1000) ANAME
 1000 FORMAT (/T2,'WARNING - ROUTINE ',A4,' CALLED WITH THERMAL INPUT',
     *            ' OUT OF RANGE')
      RETURN
      END
      SUBROUTINE UNDR (CAPC,OMC,ANNC)
C  UNDR - ROUTINE FOR ESTIMATION OF UNDERFEED STOKER BOILER COSTS
C          APPLICABLE TO :
C                      UNDERFEED STOKERS
C                      LESS THAN 75 MMBTU/HR
C                      WATERTUBE
C                      FIELD-ERECTED
C
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C ============================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      CALL LIMIT(Q,15.0,75.0,'UNDR')
      H1=11800/H
      CAPC(1)=66392.*Q**0.622*H1+2257.*Q**0.819
      CAPC(2)=53219.*Q**0.65*H1+2282.*Q**0.796
      CAPC(4)=40188.*Q**0.646*H1**0.926
      CAPC(8)=2000
      OMC(1)=ALF(CF)*(38020*ALOG(Q)+28640)*0.767
      OMC(2)=ALF(CF)*((Q+5300000.)/(99.29-Q))*0.767
      OMC(3)=ALF(CF)*((Q+4955000)/(99.23-Q))*0.767
      OMC(4)=(1.705E8*Q-2.959E8)**.5*H1**1.0028*0.767
      OMC(6)=(CF/0.6)*(Q/(1.105E-5*Q+3.69E-4))*H1**0.9*(A/10.6)**0.3
     $*0.848
      OMC(8)=(CF/0.6)*443.3*Q*H1**0.9*(A/10.6)**0.3*0.848
      OMC(16)=CF*Q*8760*FC
      CALL FNLCST(CAPC,OMC,ANNC,BCRF,1)
      RETURN
      END
      SUBROUTINE SPRD(CAPC,OMC,ANNC)
C  SPRD - ROUTINE FOR ESTIMATION OF SPREADER STOKER BOILER COSTS
C        APPLICABLE TO :
C                 SPREADER STOKERS
C                 WATERTUBE
C                 FIELD-ERECTED
C                 60-200 MMBTU/HR
C
C ============================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      CALL LIMIT(Q,60.0,200.0,'SPRD')
      H1=H/11800.
      CAPC(1)=(Q/(7.5963E-8*Q+4.7611E-5))*H1**(-0.35)
      CAPC(2)=(Q/(8.9174E-8*Q+5.5891E-5))*H1**(-0.35)
      CAPC(4)=(Q/(1.2739E-7*Q+7.9845E-5))*H1**(-0.35)
      CAPC(8)=2000
      OMC(1)=ALF(CF)*(202825+5.366*Q**2)*0.767
      OMC(2)=ALF(CF)*136900*0.767
      OMC(3)=ALF(CF)*(107003+1.873*Q**2)*0.767
      OMC(4)=(50000+1000*Q)*0.767
      OMC(6)=CF*(29303.+719.8*Q)*0.848
      OMC(8)=CF* (547320.+66038*ALOG(A/H))*(Q/150.0)**0.9754*0.38*0.848
      OMC(16)=CF*Q*8760*FC
      CALL FNLCST (CAPC,OMC,ANNC,BCRF,1)
      RETURN
      END
      SUBROUTINE PLVR(CAPC,OMC,ANNC)
C  PLVR - ROUTINE FOR ESTIMATION OF PULVERIZED COAL-FIRED BOILER COSTS
C          APPLICABLE TO :
C                        PULVERIZED COAL-FIRED
C                        WATERTUBE
C                        FIELD-ERECTED
C                        GREATER THAN 200 MMBTU/HR
C
C =============================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      CALL LIMIT (Q,200.0,700.0,'PLVR')
      CAPC(1)=(4926066.-0.00337*H**2.0)*(Q/200.)**0.712
      CAPC(2)=1547622.7+6740.026*Q-0.0024133*H**2.0
      CAPC(4)=1257434.72+6271.316*Q-0.00185721*H**2.0
      CAPC(8)=4000
      OMC(1)=ALF(CF)*(244455+1157*Q)*0.767
      OMC(2)=ALF(CF)*(213985.-20636709./Q)*0.767
      OMC(3)=ALF(CF)*(-1162910.+256604.*ALOG(Q))*0.767
      OMC(4)=(180429.+405.4*Q)*0.767
      OMC(6)=CF*(189430.+1476.7*Q)*0.848
      OMC(8)=CF* (-641.08+70679828*A/H)*(Q/200)**1.001*0.38*0.848
      OMC(16)=CF*Q*8760.*FC
      CALL FNLCST(CAPC,OMC,ANNC,BCRF,1)
      RETURN
      END
      SUBROUTINE RES1(CAPC,OMC,ANNC)
C  RES1 - ROUTINE FOR ESTIMATION OF FIRETUBE RESIDUAL-FIRED BOILER COSTS
C          APPLICABLE TO :
C                        RESIDUAL OIL-FIRED
C                        FIRETUBE
C                        PACKAGE
C                        LESS THAN 30 MMBTU/HR
C
C =============================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      CALL LIMIT(Q,0.0,30.0,'RES1')
      CAPC(1)=17360*Q**0.557
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```
    CAPC(2)=4324*Q+56177
    CAPC(4)=2317*Q+29749
    CAPC(8)=2000
    OMC(1)=ALF(CF)*105300*0.799
    IF (Q.LT.15) OMC(2)=ALF(CF)*((Q-5)/10)*68500*0.799
    IF (Q.GE.15) OMC(2)=ALF(CF)*68500*0.799
    IF (Q.LT.15) OMC(3)=ALF(CF)*(1600*Q+8000)*0.799
    IF (Q.GE.15) OMC(3)=ALF(CF)*32000*0.799
    OMC(4)=(708.7*Q+4424)*0.799
    OMC(6)=(CF/0.45)*(580*Q+3900)*0.845
    OMC(16)=CF*Q*8760*FC
    CALL FNLCST(CAPC,OMC,ANNC,BCRF,1)
    RETURN
    END
    SUBROUTINE DNG1(CAPC,OMC,ANNC)
C  DNG1 - ROUTINE FOR ESTIMATION OF DISTILLATE/NG FIRED BOILER COSTS
C      APPLICABLE TO :
C            DUAL-FIRED (DISTILLATE AND/OR NATURAL GAS)
C            FIRETUBE
C            PACKAGE
C            LESS THAN 30 MMBTU/HR
C
C ==============================================
    REAL CAPC(10),OMC(19),ANNC(5)
    COMMON /BSPEC/ Q,FLW,CF,BCRF
    COMMON /FUEL/ FC,H,S,A
    CALL LIMIT(Q,0.0,30.0,'DNG1')
    CAPC(1)=15918*Q**0.561
    CAPC(2)=4261*Q+56041
    CAPC(4)=2256*Q+28649
    CAPC(8)=2000
    OMC(1)=ALF(CF)*105300*0.799
    IF (Q.LT.15) OMC(2)=ALF(CF)*((Q-5)/10)*68500*0.799
    IF (Q.GE.15) OMC(2)=ALF(CF)*68500*0.799
    IF (Q.LT.15) OMC(3)=ALF(CF)*(1600*Q+8000)*0.799
    IF (Q.GE.15) OMC(3)=ALF(CF)*32000*0.799
    OMC(4)=(708.7*Q+4424)*0.799
    OMC(6)=(CF/0.45)*(580*Q+3900)*0.845
    OMC(16)=CF*Q*3760*FC
    CALL FNLCST(CAPC,OMC,ANNC,BCRF,1)
    RETURN
    END
    SUBROUTINE DNG2(CAPC,OMC,ANNC)
C  DNG2 - ROUTINE FOR ESTIMATION OF DISTILLATE/NG FIRED BOILER COSTS
C      APPLICABLE TO :
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C                    DUAL-FIRED (DISTILLATE AND/OR NATURAL GAS)
C                    WATERTUBE
C                    PACKAGE
C                    30-200 MMBTU/HR
C
C ==============================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      CALL LIMIT(Q,30.0,200.0,'DNG2')
      CAPC(1)=14850*Q**0.786
      CAPC(2)=54620*Q**0.361
      CAPC(4)=15952*Q**0.618
      CAPC(8)=2000
      OMC(1)=ALF(CF)*(Q**2/(8.135E-4*Q-1.585E-2))*0.799
      OMC(2)=ALF(CF)*68500*0.799
      OMC(3)=ALF(CF)*(-1267000/Q+77190)*0.799
      OMC(4)=(7185*Q**0.4241)*0.799
      OMC(6)=(CF/0.55)*(202*Q+24262)*0.845
      OMC(16)=CF*Q*8760*FC
      CALL FNLCST(CAPC,OMC,ANNC,BCRF,1)
      RETURN
      END
      SUBROUTINE RNG1(CAPC,OMC,ANNC)
C  RNG1 - ROUTINE FOR ESTIMATION OF RESIDUAL/NG FIRED BOILER COSTS
C         APPLICABLE TO :
C                    DUAL-FIRED (RESIDUAL AND/OR NATURAL GAS)
C                    WATERTUBE
C                    PACKAGE
C                    30-200 MMBTU/HR
C
C ==============================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      CALL LIMIT(Q,30.0,200.0,'RNG1')
      CAPC(1)=15925.*Q**0.775
      CAPC(2)=54833.*Q**0.364
      CAPC(4)=16561.*Q**0.613
      CAPC(8)=2000
      OMC(1)=ALF(CF)*(Q**2/(8.135E-4*Q-1.585E-2))*0.799
      OMC(2)=ALF(CF)*68500.*0.799
      OMC(3)=ALF(CF)*(-1267000./Q+77190.)*0.799
      OMC(4)=(7185.*Q**0.4241)*0.799
      OMC(6)=(CF/0.55)*(202*Q+24262)*0.845
      OMC(16)= CF*Q*8760.*FC
      CALL FNLCST(CAPC,OMC,ANNC,BCRF,1)
      RETURN
      END
      SUBROUTINE RNG2(CAPC,OMC,ANNC)
C  RNG2 - ROUTINE FOR ESTIMATION OF RESIDUAL/NG FIRED BOILER COSTS
C         APPLICABLE TO :
C                   DUAL-FIRED (RESIDUAL AND/OR NATURAL GAS)
C                   WATERTUBE
C                   FIELD-ERECTED
C                   200-700 MMBTU/HR
C
C ==================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      CALL LIMIT(Q,200.0,700.0,'RNG2')
      CAPC(1)=1024258.+8458.*Q
      CAPC(2)=579895.+5636.*Q
      CAPC(4)=515189.+4524.*Q
      CAPC(8)=2000
      OMC(1)=ALF(CF)*(173197+734*Q)*0.799
      OMC(2)=ALF(CF)*(263250.-30940000./Q)*0.799
      OMC(3)=ALF(CF)*(32029.+320.4*Q)*0.799
      OMC(4)=(50000.+250.*Q)*0.799
      OMC(6)=CF*(43671.7+479.6*Q)*0.845
      OMC(16)=CF*Q*8760.*FC
      CALL FNLCST(CAPC,OMC,ANNC,BCRF,1)
      RETURN
      END
      SUBROUTINE ESPC(CAPC,OMC,ANNC,IPFLAG)
C  ESPC - ROUTINE FOR ESTIMATION OF ESP COSTS (COAL-FIRED BOILER APPLICA
C         APPLICABLE TO :
C                   COAL-FIRED BOILER APPLICATIONS
C                   BOILERS WITH THERMAL INPUTS LESS THAN 700 MMBTU/HR
C
C =================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      CALL LIMIT (Q,30.0,700.0,'ESPC')
      SCA = 324.32*(S**(-11.256*(EFFPM**(-0.745))))
     *   *((100.-EFFPM)**(-0.366*(S**(-0.051))))*1.18178
      TPA = SCA*FLW/1000.
      IF (IPFLAG.NE.0)WRITE (6,1001) SCA,TPA
 1001 FORMAT (/T2,'SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) = ',
     *    F8.1/T2, 'TOTAL PLATE AREA (SQ FT) = ',F10.1)
      IF (Q.GE.100.) GO TO 10
      CAPC(1) = 0.02457*SCA*FLW-5.62E-10*(SCA*FLW)**2.0+0.544*FLW+26353.
      CAPC(2) = CAPC(1)*1.17
      GO TO 20
 10   IF (TPA.LT.28000.) CAPC(1) = 0.02457*SCA*FLW-5.62E-10*(SCA*FLW)
     *   **2.0+130000.+226.*Q
      IF (TPA.GE.28000.) CAPC(1)=0.00965*SCA*FLW-2.54E-11*(SCA*FLW)
     *   **2.0+130000.+226.*Q
      CAPC(2) = CAPC(1)*1.10
 20   CAPC(4) = 0.334*(CAPC(1)+CAPC(2))
      IF (Q.GT.400.) GO TO 30
      OMC(1)=ALF(CF)*(10150.+106.*Q)
      OMC(3)=ALF(CF)*(14840.+0.106*Q**2.0)
      GO TO 40
 30   OMC(1)=ALF(CF)*52600.
      OMC(2)=ALF(CF)*17000.
      OMC(3)=ALF(CF)*32000.
 40   OMC(4)=5.52E-3*(CAPC(1)+CAPC(2)+CAPC(4))
      OMC(6)=(CF/0.6)*(0.4068*TPA+2.523*Q*(UNCPM-CTRPM))
      OMC(8)= (CF/0.6)*39.42*Q*(UNCPM-CTRPM)
      CALL FNLCST(CAPC,OMC,ANNC,CRFPM,1)
      RETURN
      END
      SUBROUTINE ESPO(CAPC,OMC,ANNC,IPFLAG)
C  ESPO - ROUTINE FOR ESTIMATION OF ESP COSTS (OIL-FIRED BOILER APPLICAT
C            APPLICABLE TO :
C                       OIL-FIRED BOILER APPLICATIONS
C                       BOILERS WITH THERMAL INPUTS LESS THAN 700 MMBTU/HR
C
C ================================================
      REAL CAPC (10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      CALL LIMIT(Q,30.0,700.0,'ESPO')
      SCA=400.
      TPA=SCA*FLW/1000.
      IF (IPFLAG.NE.0) WRITE (6,1001) SCA,TPA
 1001 FORMAT (/T2,'SPECIFIC COLLECTOR AREA(SQ FT/1000 ACFM)=', F8.1/T2,
     *  'TOTAL PLATE AREA (SQ FT)= ',F10.1)
      IF (Q.GE.100) GO TO 40
      CAPC(1)=0.02457*SCA*FLW-5.62E-10*(SCA*FLW)**2+(0.544*FLW+26353)
      CAPC(2)=1.17*CAPC(1)
      GO TO 30
 40   CONTINUE
      IF (TPA.LT.28000.)CAPC(1) = 0.02457*SCA*FLW-5.62E-10*(SCA*FLW)**
     *  2.0+(0.544*FLW+26353.)
      IF (TPA.GE.28000.) CAPC(1)=0.00965*SCA*FLW-2.54E-11*(SCA*FLW)**
     *     2.0+(0.544*FLW+26353.)
      CAPC(2)=1.10*CAPC(1)
 30   CAPC(4)=0.334*(CAPC(1)+CAPC(2))
      IF (Q.GT.400.) GO TO 10
      OMC(1)= ALF(CF)*(10150.+106.*Q)
      OMC(3)= ALF(CF)*(14840.+0.106*Q**2.0)
      GO TO 20
 10   OMC(1)= ALF(CF)*52600.
      OMC(2)= ALF(CF)*17000.
      OMC(3)= ALF(CF)*32000.
 20   OMC(4)=5.52E-3*(CAPC(1)+CAPC(2)+CAPC(4))
      OMC(6)=(CF/0.6)*(0.1068*TPA+2.523*Q*(UNCPM-CTRPM))
      CALL FNLCST (CAPC,OMC,ANNC,CRFPM,1)
      RETURN
      END
      SUBROUTINE FF(CAPC,OMC,ANNC)
C  FF - ROUTINE FOR ESTIMATION OF FABRIC FILTER COSTS
C          APPLICABLE TO :
C                     COAL FIRED BOILER APPLICATIONS
C                     BOILERS WITH THERMAL INPUTS FROM 30 TO 700 MMRTU/HR
C
C =================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      CALL LIMIT(Q,30.0,700.0,'FF')
      CAPC(1)=8.34*FLW**0.966
      CAPC(2)=168531.*ALOG(FLW)-1506523.
      CAPC(4)=24.99*FLW**0.821
      IF (Q.GT.400) GO TO 10
      OMC(1)=ALF(CF)*(10150.+106.*Q)
      OMC(3)=ALF(CF)*(14840.+0.106*Q**2.0)
      GO TO 20
 10   OMC(1)=ALF(CF)*52600.
      OMC(2)=ALF(CF)*17000.
      OMC(3)=ALF(CF)*32000.
 20   OMC(4)=0.278*FLW**0.997
      OMC(6)=(CF/0.6)*(0.740*FLW**0.953)
      OMC(8)=(CF/0.6)*(39.42*Q)*(UNCPM-CTRPM)
      CALL FNLCST(CAPC,OMC,ANNC,CRFPM,1)
      RETURN
      END
      SUBROUTINE VS(CAPC,OMC,ANNC)
C  VS - ROUTINE FOR ESTIMATION OF VENTURI SCRUBBER COSTS
C         APPLICABLE TO :
C                    COAL-FIRED BOILER APPLICATIONS
C                    PM REMOVAL ONLY (NO SO2 REMOVAL)
C                    BOILERS WITH THERMAL INPUTS FROM 30 TO 700 MMBTU/HR
C
C =====================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      CALL LIMIT(Q,30.0,700.0,'VS')
      CAPC(1)=26916.+2.294*FLW
      CAPC(2)=13904.+1.653*FLW
      CAPC(4)=15463.+1.285*FLW
      IF (Q.GT.400) GO TO 10
      OMC(1)=ALF(CF)*(10150.+106.*Q)
      GO TO 20
   10 OMC(1)=ALF(CF)*52000
      OMC(2)=ALF(CF)*17000
   20 OMC(3)=4525.+104.4*Q
      OMC(6)=(CF/0.6)*304.3*Q**0.938
      OMC(8)=(CF/0.6)*39.42*Q*(UNCPM-CTRPM)
      CALL FNLCST(CAPC,OMC,ANNC,CRFPM,1)
      RETURN
      END
      SUBROUTINE SM(CAPC,OMC,ANNC)
C  SM - ROUTINE FOR ESTIMATION OF SINGLE MECHANICAL (MULTI-CLONE)
C        COLLECTOR COSTS
C          APPLICALBE TO :
C                    COAL-FIRED BOILER APPLICATIONS
C                    BOILERS WITH THERMAL INPUTS FROM 30 TO 700 MMBTU/HR
C
C =====================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      CAPC(1)=32.53*FLW**0.7518
      CAPC(4)=CAPC(1)/3.0
      OMC(1)=ALF(CF)*(5075+53.0*Q)
      OMC(2)=OMC(1)*0.15
      OMC(3)=ALF(CF)*(7420+0.053*Q*Q)
      OMC(4)=0.005*(CAPC(1)+CAPC(4))
      OMC(5)=0.286*FLW*CF
      OMC(8)=(CF/0.6)*39.42*Q*(UNCPM-CTRPM)
      CALL FNLCST(CAPC,OMC,ANNC,CRFPM,1)
      RETURN
      END
      SUBROUTINE DM(CAPC,OMC,ANNC)
C  DM - ROUTINE FOR ESTIMATION OF DUAL MECHANICAL (TWO MULTICLONES IN SE
C         COLLECTOR COSTS
C           APPLICABLE TO :
C                      COAL-FIRED BOILERS APPLICATIONS
C                      BOILERS WITH THERMAL INPUTS FROM 30 TO 700 MMBTU/HR
C
C =====================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      CAPC(1)=24.54*FLW**0.8130
      CAPC(4)=CAPC(1)/3.0
      OMC(1)=ALF(CF)*(5075+53.0*Q)
      OMC(2)=OMC(1)*0.15
      OMC(3)=ALF(CF)*(7420+0.053*Q*Q)
      OMC(4)=0.005*(CAPC(1)+CAPC(4))
      OMC(5)=0.3818*CF*FLW
      OMC(8)=(CF/0.6)*39.42*Q*(UNCPM-CTRPM)
      CALL FNLCST(CAPC,OMC,ANNC,CRFPM,1)
      RETURN
      END
      SUBROUTINE SSS (CAPC,OMC,ANNC)
C  SSS - ROUTINE FOR ESTIMATION OF SIDESTREAM SEPARATOR COSTS
C           APPLICABLE TO :
C                      COAL-FIRED BOILER APPLICATIONS
C                      BOILERS WITH THERMAL INPUTS FROM 30 TO 700 MMBTU/HR
C
C =====================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,CRF
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      CAPC(1)=41.3*FLW**0.7869
      CAPC(4)=CAPC(1)/3.0
      OMC(1)=ALF(CF)*(7105+74.2*Q)
      OMC(2)=OMC(1)*0.15
      OMC(3)=ALF(CF)*(10390+0.074*Q*Q)+0.0554*FLW**0.997
      OMC(4)=0.005*(CAPC(1)+CAPC(4))
      OMC(5)=0.286*FLW*CF+(CF/0.6)*0.160*FLW**0.953
      OMC(8)=(CF/0.6)*39.42*Q*(UNCPM-CTRPM)
      CALL FNLCST(CAPC,OMC,ANNC,CRFPM,1)
      RETURN
      END
      SUBROUTINE DA (CAPC,OMC,ANNC,IPFLAG)
C  DA - ROUTINE FOR ESTIMATION OF DUAL ALKALI FGD COSTS
C         APPLICABLE TO :
C                    COAL- AND OIL-FIRED BOILER APPLICATIONS
C                    WITH PRIOR PM REMOVAL FOR COAL-FIRED APPLICATIONS
C                    NO SIZE LIMITATIONS
C
C =================================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      COMMON /SO2/ UNCSO2,CTRSO2,EFFSO2,CRFSO2
      COMMON /COSTS/ DLR,SLR,AMLR,ELEC,WTR,ALIME,ALS,ALYE,SASH,SLDG,
     *     SWD,ALWD
      H2=H*2.3257
      Q2=Q*0.2930
      FLW2=FLW*4.720E-4
      SLDG2=SLDG*0.0011013
      WTR2=WTR*0.2641
      ALIME2=ALIME*0.0011013
      SASH2=SASH*0.0011013
      S1=S*EFFSO2*100./H2
      S2=S1*Q2*3.6
      IF (IPFLAG.NE.0) WRITE (6,1000)S1,S2
 1000 FORMAT (/T2,'S STAR (METRIC)=',F10.3/T2,'S DSTAR (METRIC)=',F10.3)
      CAPC(3)=45200.*FLW2**0.61+83118*S2**0.39
      IF (Q2.LE.58.6) CAPC(7)=1.48*CAPC(3)+93600
      IF (Q2.GT.58.6) CAPC(7)=1.48*CAPC(3)+130000
      OMC(1)=105000.
      OMC(2)=21000.
      OMC(3)= 0.08*CAPC(3)
      OMC(5)=ELEC*(2.94*FLW2)*(0.121*S1+0.861)*8760.*CF
      OMC(7)=WTR2*(0.197*FLW2+0.30)*(0.997+0.119*ALOG(S1))*8760.*CF
      OMC(9)=SLDG2*(7.73*S2-3.34)*8760.*CF
      IF (S1.LT.0.24) OMC(11)=SASH2*(1.13*FLW2-2.06)*(0.41-0.70*
     *    (0.24-S1)**1.74)*8760.*CF
      IF (S1.GE.0.24) OMC(11)=SASH2*(1.13*FLW2-2.06)*(0.70*(S1-0.24)
     *     **1.74+0.41)*8760.*CF
      OMC(13)=ALIME2*(1.61*S2-0.85)*8760*CF
      DO 10 I=1,16
 10   OMC(17)=OMC(17)+OMC(I)
```

```
      OMC(18)=0.56*OMC(1)+0.26*(OMC(2)+OMC(3))
      OMC(19)=OMC(17)+OMC(18)
      CAPC(9)=0.25*OMC(17)
      CAPC(10)=CAPC(7)+CAPC(9)
      CALL FNLCST (CAPC,OMC,ANNC,CRFSO2,0)
      RETURN
      END
      SUBROUTINE DAC (CAPC,OMC,ANNC,IPFLAG)
C  DAC - ROUTINE FOR ESTIMATION OF COMBINED DUAL ALKALI FGD WITH
C         PROVISIONS FOR PM REMOVAL
C         APPLICABLE TO :
C                    COAL- AND OIL-FIRED BOILER APPLICATIONS
C                    NO PRIOR PM REMOVAL REQUIRED
C                    NO SIZE LIMITATIONS
C
C =====================================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      COMMON /SO2/ UNCSO2,CTRSO2,EFFSO2,CRFSO2
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      COMMON /COSTS/ DLR,SLR,AMLR,ELEC,WTR,ALIME,ALS,ALYE,SASH,SLDG,
     *    SWD,ALWD
      H2=H*2.3257
      Q2=Q*0.2930
      FLW2=FLW*4.720E-4
      SLDG2=SLDG*0.0011013
      WTR2=WTR*0.2641
      ALIME2=ALIME*0.0011013
      SASH2=SASH*0.0011013
      PM2U=UNCPM*430.39
      PM2C=CTRPM*430.39
      S1=S*EFFSO2*100.0/H2
      S2=S1*Q2*3.6
      P1=3.6E-3*Q2*(1.2*PM2U-2.*PM2C)
      IF (IPFLAG.NE.0) WRITE (6,1000) S1,S2,P1
 1000 FORMAT (/T2,'S STAR (METRIC)=',F10.3/
     *        T2,'S DSTAR (METRIC)=',F10.3/
     *        T2,'P DSTAR (METRIC)=',F10.3)
      CAPC(3)=74370.+9.02E3*FLW2-39.5*FLW2**2+13340*FLW2**0.528+32.32E3*
     *  S2**0.362+54.06E3*(7.73*S2-3.34+P1)**0.278+4094*FLW2**0.834
      IF (Q2.LE.58.6) CAPC(7)=1.48*CAPC(3)+93600
      IF (Q2.GT.58.6) CAPC(7)=1.48*CAPC(3)+130000
      OMC(1)=105000
      OMC(2)=21000
      OMC(3)=0.08*CAPC(3)
      OMC(5)=ELEC*6.11*FLW2*(0.121*S1+0.861)*8760*CF
      OMC(7)=WTR2*(0.197*FLW2+0.30)*(0.997+0.119*ALOG(S1))*8760*CF
      OMC(9)=SLDG2*(7.73*S2-3.34+F1)*8760*CF
      IF (S1.LE.0.24) OMC(11)=SASH2*(1.13*FLW2-2.06)*(0.41-0.70*(0.24-
     *     S1)**1.74)*8760*CF
      IF (S1.GT.0.24) OMC(11)=SASH2*(1.13*FLW2-2.06)*(0.70*
     *     (S1-0.24)**1.74+0.41)*8760.0*CF
      OMC(13)=ALIME2*(1.61*S2-0.85)*8760*CF
      DO 10 I=1,16
   10 OMC(17)=OMC(17)+OMC(I)
      OMC(18)=0.56*OMC(1)+0.26*(OMC(2)+OMC(3))
      OMC(19)=OMC(17)+OMC(18)
      CAPC(9)=0.25*OMC(17)
      CAPC(10)=CAPC(7)+CAPC(9)
      CALL FNLCST(CAPC,OMC,ANNC,CRFSO2,0)
      RETURN
      END
      SUBROUTINE NATH(CAPC,OMC,ANNC,IPFLAG)
C  NATH - ROUTINE FOR ESTIMATION OF SODIUM THROWAWAY FDG COSTS
C         APPLICABLE TO :
C                    OIL-FIRED BOILER APPLICATIONS
C                    NO SIZE LIMITATIONS
C
C =============================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      COMMON /SO2/ UNCSO2,CTRSO2,EFFSO2,CRFSO2
      COMMON /COSTS/ DLR,SLR,AMLR,ELEC,WTR,ALIME,ALS,ALYE,SASH,SLDG,
     *     SWD,ALWD
      H2=H*2.3257
      Q2=Q*0.2930
      FLW2=FLW*4.720E-4
      WTR2=WTR*0.2641
      SLDG2=SLDG*0.0011013
      SASH2=SASH*0.0011013
      ALW2=ALWD*0.2641
      S1=S*EFFSO2*100.0/H2
      S2=S1*Q2*3.6
      IF (IPFLAG.NE.0) WRITE (6,1000)S1,S2
 1000 FORMAT(/T2,'S STAR (METRIC)=',F10.3/T2,'S DSTAR (METRIC)=',F10.3)
      CAPC(3)=44000*FLW2**0.62+20600*S2**0.427
      IF (Q2.LE.58.6) CAPC(7)=CAPC(3)*1.48+74400
      IF(Q2.GT.58.6) CAPC(7)=CAPC(3)*1.48+112800
      OMC(1)=105000
      OMC(2)=21000
      OMC(3)=0.08*(CAPC(3))
      OMC(5)=ELEC*(4.26*FLW2-2.56)*(0.65+0.31*S1)*8760*CF
      OMC(7)=WTR2*(0.776*FLW2-.720)*(.213+.684*S1)*8760*CF
      OMC(9)=SLDG2*(.16+4.53*S2)*8760*CF
      OMC(10)=ALW2*(0.086*S2)*8760.*CF
      OMC(11)=SASH2*(8.03+3.5*S2)*8760*CF
      DO 10 I=1,16
   10 OMC(17)=OMC(17)+OMC(I)
      OMC(18)=0.56*OMC(1)+.26*(OMC(2)+OMC(3))
      OMC(19)=OMC(17)+OMC(18)
      CAPC(9)=.25*OMC(17)
      CAPC(10)=CAPC(7)+CAPC(9)
      CALL FNLCST(CAPC,OMC,ANNC,CRFSO2,0)
      RETURN
      END
      SUBROUTINE DS(CAPC,OMC,ANNC,IPFLAG)
C  DS - ROUTINE FOR ESTIMATION OF DRY SCRUBBING FGD COSTS
C        APPLICABLE TO :
C                   LOW SULFUR-COAL FIRED BOILER APPLICATIONS
C                   NO PRIOR PM REMOVAL REQUIRED
C                   NO SIZE LIMITATIONS
C
C ====================================================
      REAL CAPC(10),OMC(19),ANNC(5)
      COMMON /BSPEC/ Q,FLW,CF,BCRF
      COMMON /FUEL/ FC,H,S,A
      COMMON /SO2/ UNCSO2,CTRSO2,EFFSO2,CRFSO2
      COMMON /PM/ UNCPM,CTRPM,EFFPM,CRFPM
      COMMON /COSTS/ DLR,SLR,ANLR,ELEC,WTR,ALIME,ALS,ALYE,SASH,SLDG,
     *    SWD,ALWD
      H2=H*2.3257
      Q2=Q*0.2930
      FLW2=FLW*4.720E-4
      WTR2=WTR*0.2641
      ALIME2=ALIME*0.0011013
      PM2U=UNCPM*430.39
      SWD2=SWD*0.0011013
      PF=Q*UNCPM*0.454
      S1=S*EFFSO2*100.0/H2
      S2=S1*Q2*3.6
      IF (IPFLAG .NE. 0) WRITE (6,1000) S1,S2
 1000 FORMAT (/T2,'S STAR (METRIC) = ',F10.3/
     *         T2,'S DSTAR (METRIC) = ',F10.3)
```

```
      CAPC(3)=55600.*FLW2**0.51+21600.*S2**0.4+33327*FLW2**0.89
      IF (Q2 .LE. 58.6) CAPC(7)=1.40*CAPC(3)+110100.
      IF (Q2 .GT. 58.6)  CAPC(7)=1.60*CAPC(3)
      OMC(1)=105000.
      OMC(2)=21000.
      OMC(3)=0.08*(55600.*FLW2**0.51+21600.*S2**0.4) +14840.+
     *        1.23*Q2**2.0+578.*FLW2**0.997
      OMC(5)=ELEC*(6.14*FLW2**0.82)*8760.*CF
      OMC(7)=WTR2*(0.144*FLW2)*8760.*CF
      OMC(8)=SWD2*((0.035*EFFSO2+3.02)*S2+PF   *EFFPM/100.)*8760.*CF
      OMC(13)=ALIME2*(1.83*ALOG(EFFSO2)-5.3)*S2*8760.*CF
      DO 10 I=1,16
10    OMC(17)=OMC(17)+OMC(I)
      OMC(18)=0.56*OMC(1)+0.26*(OMC(2)+OMC(3))
      OMC(19)=OMC(17)+OMC(18)
      CAPC(9)=0.25*OMC(17)
      CAPC(10)=CAPC(7)+CAPC(9)
      CALL FNLCST(CAPC,OMC,ANNC,CRFSO2,0)
      RETURN
      END
/*
//GO.SYSIN DD *
```

APPENDIX C

MODEL BOILER COST TABLES

This appendix presents a detailed cost breakdown of the boiler, SO_2 control and PM control costs for all the model boilers presented in Chapters 3 and 4. The terms for which many of the abbreviations stand for are presented in the algorithm abbreviations in Table A-2. However, some variations are present. These terms and their abbreviations can be found within the FORTRAN computer program COST (Appendix B).

Each cost summary table presents three totals. The first total is the total capital costs. The second total is the total annual O&M costs and the third total is the total annualized costs.

HSC-30-Unc, Unc

```
MODEL BOILER   1                           4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=             PM ROUTINE=              FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=       30.0 FLW= 11029. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.0   CTR=  0.0   EFF=   0.0  CRF= 0.0
SO2 EMISSIONS
   UNC=   0.0   CTR=  0.0   EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     1
--------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP          587246.            0.             0.             0.         587246.
INST          519713.            0.             0.             0.         519713.
TD           1106959.            0.             0.             0.        1106959.
IND           361673.            0.             0.             0.         361673.
TDI          1468632.            0.             0.             0.        1468632.
CONT          293726.            0.             0.             0.         293726.
TK           1762358.            0.             0.             0.        1762358.
LAND            2000.            0.             0.             0.           2000.
WC             92986.            0.             0.             0.          92986.
TOTL         1857344.            0.             0.             0.        1857344.

DL             90863.            0.             0.             0.          90863.
SPRV           44001.            0.             0.             0.          44001.
MANT           41173.            0.             0.             0.          41173.
SP             53245.            0.             0.             0.          53245.
ELEC               0.            0.             0.             0.              0.
UC             36296.            0.             0.             0.          36296.
WTR                0.            0.             0.             0.              0.
SW             11271.            0.             0.             0.          11271.
SLDG               0.            0.             0.             0.              0.
LW                 0.            0.             0.             0.              0.
SC                 0.            0.             0.             0.              0.




LMS                0.            0.             0.             0.              0.
LIME               0.            0.             0.             0.              0.
NH3                0.            0.             0.             0.              0.
LYE                0.            0.             0.             0.              0.
FUEL          285401.            0.             0.             0.         285401.
TDOM          562250.            0.             0.             0.         562250.
OH             86872.            0.             0.             0.          86872.
TOTL          649122.            0.             0.             0.         649122.

CR            231750.            0.             0.             0.         231750.
WCC             9299.            0.             0.             0.           9299.
MISC           70494.            0.             0.             0.          70494.
TCC           311543.            0.             0.             0.         311543.
TOTL          960665.            0.             0.             0.         960665.
```

HSC-30-Unc, SM

```
MODEL BOILER   2                           4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=             PM ROUTINE= SM           FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11029. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.400 EFF=  39.10 CRF= 0.1315
SO2 EMISSIONS
   UNC=   0.0   CTR=  0.0   EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     2
--------------------------------------------------------------------------------
ITEM         BOILER        NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP          587246.            0.             0.          35602.        622848.
INST          519713.            0.             0.              0.        519713.
TD           1106959.            0.             0.          35602.       1142560.
IND           361673.            0.             0.          11867.        373541.
TDI          1468632.            0.             0.          47469.       1516100.
CONT          293726.            0.             0.           9494.        303220.
TK           1762358.            0.             0.          56963.       1819320.
LAND            2000.            0.             0.              0.          2000.




WC             92986.            0.             0.           3446.         96432.
TOTL         1857344.            0.             0.          60409.       1917752.

DL             90863.            0.             0.           4999.         95862.
SPRV           44001.            0.             0.            750.         44751.
MANT           41173.            0.             0.           5601.         46773.
SP             53245.            0.             0.            237.         53482.
ELEC               0.            0.             0.           1893.          1893.
UC             36296.            0.             0.              0.         36296.
WTR                0.            0.             0.              0.             0.
SW             11271.            0.             0.            304.         11575.
SLDG               0.            0.             0.              0.             0.
LW                 0.            0.             0.              0.             0.
SC                 0.            0.             0.              0.             0.
LMS                0.            0.             0.              0.             0.
LIME               0.            0.             0.              0.             0.
NH3                0.            0.             0.              0.             0.
LYE                0.            0.             0.              0.             0.
FUEL          285401.            0.             0.              0.        285401.
TDOM          562250.            0.             0.          13783.        576033.
OH             86872.            0.             0.           4512.         91384.
TOTL          649122.            0.             0.          18295.        667417.

CR            231750.            0.             0.           7491.        239241.
WCC             9299.            0.             0.            345.          9643.
MISC           70494.            0.             0.           2279.         72773.
TCC           311543.            0.             0.          10114.        321657.
TOTL          960665.            0.             0.          28409.        989074.
```

HSC-30-Unc, SSS

```
MODEL BOILER   3                          4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=               PM ROUTINE= SSS          FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11029. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.200 EFF=  69.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=   0.0   CTR=  0.0   EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80



COST SUMMARY TABLE - RUN NO.     3
-------------------------------------------------------------------------------
ITEM          BOILER        NOX CONTROL   SO2 CONTROL   PM CONTROL      TOTAL
-------------------------------------------------------------------------------

EQUP          587246.            0.            0.          62666.        649912.
INST          519713.            0.            0.              0.        519713.
TD           1106959.            0.            0.          62666.       1169624.
IND           361673.            0.            0.          20889.        382562.
TDI          1468632.            0.            0.          83554.       1552186.
CONT          293726.            0.            0.          16711.        310437.
TK           1762358.            0.            0.         100265.       1862623.
LAND            2000.            0.            0.              0.          2000.
WC             92986.            0.            0.           5119.         98105.
TOTL         1857344.            0.            0.         105384.       1962727.

DL             90863.            0.            0.           6998.         97861.
SPRV           44001.            0.            0.           1050.         45051.
MANT           41173.            0.            0.           8437.         49609.
SP             53245.            0.            0.            418.         53663.
ELEC               0.            0.            0.           3032.          3032.
UC             36296.            0.            0.              0.         36296.
WTR                0.            0.            0.              0.             0.
SW             11271.            0.            0.            540.         11812.
SLDG               0.            0.            0.              0.             0.
LW                 0.            0.            0.              0.             0.
SC                 0.            0.            0.              0.             0.
LMS                0.            0.            0.              0.             0.
LIME               0.            0.            0.              0.             0.
NH3                0.            0.            0.              0.             0.
LYE                0.            0.            0.              0.             0.
FUEL          285401.            0.            0.              0.        285401.
TDOM          562250.            0.            0.          20475.        582724.
OH             86872.            0.            0.           6494.         93366.
TOTL          649122.            0.            0.          26969.        676090.

CR            231750.            0.            0.          13185.        244935.
WCC             9299.            0.            0.            512.          9810.
MISC           70494.            0.            0.           4011.         74505.
TCC           311543.            0.            0.          17707.        329250.
TOTL          960665.            0.            0.          44676.       1005341.
```

HSC-30-Unc, VS

```
MODEL BOILER   4                                   4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                    PM ROUTINE= VS            FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=       30.0 FLW= 11029. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.100 EFF=  84.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   0.0   CTR=  0.0   EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     4
--------------------------------------------------------------------------------------------
ITEM           BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
--------------------------------------------------------------------------------------------

EQUP           587246.             0.              0.            52217.         639463.
INST           519713.             0.              0.            32135.         551848.
TD            1106959.             0.              0.            84353.        1191311.
IND            361673.             0.              0.            29636.         391309.
TDI           1468632.             0.              0.           113988.        1582620.
CONT           293726.             0.              0.            22798.         316524.
TK            1762358.             0.              0.           136786.        1899143.
LAND             2000.             0.              0.                0.           2000.
WC              92986.             0.              0.             6427.          99413.
TOTL          1857344.             0.              0.           143212.        2000556.

DL              90863.             0.              0.             9998.         100860.
SPRV            44001.             0.              0.                0.          44001.
MANT            41173.             0.              0.             7657.          48830.
SP              53245.             0.              0.                0.          53245.
ELEC                0.             0.              0.                0.              0.
UC              36296.             0.              0.             7393.          43690.
WTR                 0.             0.              0.                0.              0.
SW              11271.             0.              0.              659.          11930.
SLDG                0.             0.              0.                0.              0.
LW                  0.             0.              0.                0.              0.
SC                  0.             0.              0.                0.              0.
LMS                 0.             0.              0.                0.              0.
LIME                0.             0.              0.                0.              0.
NH3                 0.             0.              0.                0.              0.




LYE                 0.             0.              0.                0.              0.
FUEL           285401.             0.              0.                0.         285401.
TDOM           562250.             0.              0.            25707.         587956.
OH              86872.             0.              0.             7589.          94461.
TOTL           649122.             0.              0.            33296.         682418.

CR             231750.             0.              0.            17987.         249737.
WCC              9299.             0.              0.              643.           9941.
MISC            70494.             0.              0.             5471.          75966.
TCC            311543.             0.              0.            24101.         335644.
TOTL           960665.             0.              0.            57397.        1018062.
```

HSC-30-Unc, ESP

```
MODEL BOILER   5                           4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                 PM ROUTINE= ESPC         FLOW FLAG=    1

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =    117.3
TOTAL PLATE AREA (SQ FT) =      1293.3
BOILER SPECIFICATIONS
   Q=       30.0 FLW= 11029. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      1.81 H=   11800. S=      3.54 A=    10.58
PM EMISSIONS
   UNC=  0.657 CTR=  0.050 EFF=  92.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=   0.0   CTR=  0.0   EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     5
-----------------------------------------------------------------------------------
ITEM           BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
-----------------------------------------------------------------------------------

EQUP          587246.             0.             0.            63190.       650436.
INST          519713.             0.             0.            73932.       593645.
TD           1106959.             0.             0.           137122.      1244081.
IND           361673.             0.             0.            45799.       407472.
TDI          1468632.             0.             0.           182921.      1651553.
CONT          293726.             0.             0.            36584.       330311.
TK           1762358.             0.             0.           219506.      1981863.
LAND            2000.             0.             0.                0.          2000.




WC             92986.             0.             0.             5875.         98861.
TOTL         1857344.             0.             0.           225380.      2082724.

DL             90863.             0.             0.             9998.        100860.
SPRV           44001.             0.             0.                0.         44001.
MANT           41173.             0.             0.            11202.         52374.
SP             53245.             0.             0.             1010.         54255.
ELEC               0.             0.             0.                0.             0.
UC             36296.             0.             0.              572.         36868.
WTR                0.             0.             0.                0.             0.
SW             11271.             0.             0.              718.         11989.
SLDG               0.             0.             0.                0.             0.
LW                 0.             0.             0.                0.             0.
SC                 0.             0.             0.                0.             0.
LMS                0.             0.             0.                0.             0.
LIME               0.             0.             0.                0.             0.
NH3                0.             0.             0.                0.             0.
LYE                0.             0.             0.                0.             0.
FUEL          285401.             0.             0.                0.        285401.
TDOM          562250.             0.             0.            23499.        585748.
OH             86872.             0.             0.             8774.         95645.
TOTL          649122.             0.             0.            32272.        681394.

CR            231750.             0.             0.            28865.        260615.
WCC             9299.             0.             0.              587.          9886.
MISC           70494.             0.             0.             8780.         79275.
TCC           311543.             0.             0.            38233.        349776.
TOTL          960665.             0.             0.            70505.       1031169.
```

HSC-30-DA(50), DA/PM

```
MODEL BOILER   6                               4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DAC            PM ROUTINE=                FLOW FLAG=    1

S STAR (METRIC)=      0.645
S DSTAR (METRIC)=    20.409
P DSTAR (METRIC)=     8.014
BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11029. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.100 EFF=  84.80 CRF= 0.1315




SO2 EMISSIONS
   UNC=   5.700 CTR=  2.850 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     6
-------------------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
-------------------------------------------------------------------------------------------

EQUP        587246.               0.              0.             0.          587246.
INST        519713.               0.              0.             0.          519713.
TD         1106959.               0.         487199.             0.         1594157.
IND         361673.               0.              0.             0.          361673.
TDI        1468632.               0.              0.             0.         1468632.
CONT        293726.               0.              0.             0.          293726.
TK         1762358.               0.         814654.             0.         2577012.
LAND          2000.               0.              0.             0.            2000.
WC           92986.               0.          47745.             0.          140731.
TOTL       1857344.               0.         862399.             0.         2719743.

DL           90863.               0.         105000.             0.          195863.
SPRV         44001.               0.          21000.             0.           65001.
MANT         41173.               0.          38976.             0.           80149.
SP           53245.               0.              0.             0.           53245.
ELEC             0.               0.           4050.             0.            4050.
UC           36296.               0.              0.             0.           36296.
WTR              0.               0.            261.             0.             261.
SW           11271.               0.              0.             0.           11271.
SLDG             0.               0.          14104.             0.           14104.
LW               0.               0.              0.             0.               0.
SC               0.               0.           1106.             0.            1106.
LMS              0.               0.              0.             0.               0.
LIME             0.               0.           6485.             0.            6485.
NH3              0.               0.              0.             0.               0.
LYE              0.               0.              0.             0.               0.
FUEL        285401.               0.              0.             0.          285401.
TDOM        562250.               0.         190981.             0.          753231.
OH           86872.               0.          74394.             0.          161266.
TOTL        649122.               0.         265375.             0.          914497.

CR          231750.               0.         107127.             0.          338877.
WCC           9299.               0.           4775.             0.           14073.
MISC         70494.               0.          32586.             0.          103080.
TCC         311543.               0.         144488.             0.          456031.




TOTL        960665.               0.         409863.             0.         1370527.
```

HSC-30-DA(50), ESP

```
MODEL BOILER   7                             4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DA            PM ROUTINE= ESPC          FLOW FLAG=    1


S STAR (METRIC)=      0.645
S DSTAR (METRIC)=     20.409

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =     117.3
TOTAL PLATE AREA (SQ FT) =      1293.3
BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11029. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.050 EFF=  92.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  2.850 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     7
--------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
--------------------------------------------------------------------------------


EQUP          587246.             0.              0.         63190.       650436.
INST          519713.             0.              0.         73932.       593645.
TD           1106959.             0.         393131.        137122.      1637212.
IND           361673.             0.              0.         45799.       407472.
TDI          1468632.             0.              0.        182921.      1651553.
CONT          293726.             0.              0.         36584.       330311.
TK           1762358.             0.         675434.        219506.      2657297.
LAND            2000.             0.              0.             0.         2000.
WC             92986.             0.          45165.          5875.       144025.
TOTL         1857344.             0.         720599.        225380.      2803322.

DL             90863.             0.         105000.          9998.       205860.
SPRV           44001.             0.          21000.             0.        65001.
MANT           41173.             0.          31451.         11202.        83825.
SP             53245.             0.              0.          1010.        54255.




ELEC               0.             0.           1949.             0.         1949.
UC             36296.             0.              0.           572.        36868.
WTR                0.             0.            261.             0.          261.
SW             11271.             0.              0.           718.        11989.
SLDG               0.             0.          13408.             0.        13408.
LW                 0.             0.              0.             0.            0.
SC                 0.             0.           1106.             0.         1106.
LMS                0.             0.              0.             0.            0.
LIME               0.             0.           6485.             0.         6485.
NH3                0.             0.              0.             0.            0.
LYE                0.             0.              0.             0.            0.
FUEL          285401.             0.              0.             0.       285401.
TDOM          562250.             0.         180659.         23499.       766407.
OH             86872.             0.          72437.          8774.       168083.
TOTL          649122.             0.         253096.         32272.       934490.

CR            231750.             0.          88820.         28865.       349435.
WCC             9299.             0.           4516.           587.        14403.
MISC           70494.             0.          27017.          8780.       106292.
TCC           311543.             0.         120353.         38233.       470129.
TOTL          960665.             0.         373449.         70505.      1404617.
```

HSC-30-DA(90), DA/PM

```
MODEL BOILER   8                              4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DAC          PM ROUTINE=                FLOW FLAG=    1

S STAR (METRIC)=      1.161
S DSTAR (METRIC)=    36.737
P DSTAR (METRIC)=     8.014
BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11029. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=,  0.657 CTR=  0.100 EFF=  84.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  0.570 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     6
-------------------------------------------------------------------------------



ITEM          BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL      TOTAL
-------------------------------------------------------------------------------

EQUP          587246.              0.              0.              0.         587246.
INST          519713.              0.              0.              0.         519713.
TD           1106959.              0.         548604.              0.        1655563.
IND           361673.              0.              0.              0.         361673.
TDI          1468632.              0.              0.              0.        1468632.
CONT          293726.              0.              0.              0.         293726.
TK           1762358.              0.         905534.              0.        2667892.
LAND            2000.              0.              0.              0.           2000.
WC             92986.              0.          53346.              0.         146332.
TOTL         1857344.              0.         958880.              0.        2816224.

DL             90863.              0.         105000.              0.         195863.
SPRV           44001.              0.          21000.              0.          65001.
MANT           41173.              0.          43888.              0.          85061.
SP             53245.              0.              0.              0.          53245.
ELEC               0.              0.           4320.              0.           4320.
UC             36296.              0.              0.              0.          36296.
WTR                0.              0.            280.              0.            280.
SW             11271.              0.              0.              0.          11271.
SLDG               0.              0.          25062.              0.          25062.
LW                 0.              0.              0.              0.              0.
SC                 0.              0.           2024.              0.           2024.
LMS                0.              0.              0.              0.              0.
LIME               0.              0.          11811.              0.          11811.
NH3                0.              0.              0.              0.              0.
LYE                0.              0.              0.              0.              0.
FUEL          285401.              0.              0.              0.         285401.
TDOM          562250.              0.         213385.              0.         775635.
OH             86872.              0.          75671.              0.         162543.
TOTL          649122.              0.         289056.              0.         938178.

CR            231750.              0.         119078.              0.         350828.
WCC             9299.              0.           5335.              0.          14633.
MISC           70494.              0.          36221.              0.         106716.
TCC           311543.              0.         160634.              0.         472177.
TOTL          960665.              0.         449690.              0.        1410354.
```

HSC-30-DA(90), ESP

```
MODEL BOILER   9                                   4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DA                 PM ROUTINE= ESPC          FLOW FLAG=    1




S STAR (METRIC)=      1.161
S DSTAR (METRIC)=    36.737

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =    117.3
TOTAL PLATE AREA (SQ FT) =      1293.3
BOILER SPECIFICATIONS
   G=       30.0 FLW= 11029. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.050 EFF=  92.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  0.570 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     9
---------------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------------

EQUP          587246.             0.              0.          63190.        650436.
INST          519713.             0.              0.          73932.        593645.
TD           1106959.             0.         462560.         137122.       1706641.
IND           361673.             0.              0.          45799.        407472.
TDI          1468632.             0.              0.         182921.       1651553.
CONT          293726.             0.              0.          36584.        330311.
TK           1762358.             0.         778189.         219506.       2760052.
LAND            2000.             0.              0.              0.          2000.
WC             92986.             0.          50891.           5875.        149752.
TOTL         1857344.             0.         829080.         225380.       2911804.

DL             90863.             0.         105000.           9998.        205860.
SPRV           44001.             0.          21000.              0.         65001.
MANT           41173.             0.          37005.          11202.         89379.
SP             53245.             0.              0.           1010.         54255.
ELEC               0.             0.           2079.              0.          2079.
UC             36296.             0.              0.            572.         36868.
WTR                0.             0.            280.              0.           280.
SW             11271.             0.              0.            718.         11989.
SLDG               0.             0.          24367.              0.         24367.
LW                 0.             0.              0.              0.             0.
SC                 0.             0.           2024.              0.          2024.



LMS                0.             0.              0.              0.             0.
LIME               0.             0.          11811.              0.         11811.
NH3                0.             0.              0.              0.             0.
LYE                0.             0.              0.              0.             0.
FUEL          285401.             0.              0.              0.        285401.
TDOM          562250.             0.         203565.          23499.        789313.
OH             86872.             0.          73881.           8774.        169527.
TOTL          649122.             0.         277446.          32272.        958840.

CR            231750.             0.         102332.          28865.        362947.
WCC             9299.             0.           5089.            587.         14975.
MISC           70494.             0.          31128.           8780.        110402.
TCC           311543.             0.         138548.          38233.        488324.
TOTL          960665.             0.         415994.          70505.       1447162.
```

HSC-75-Unc, Unc

```
MODEL BOILER  10                            4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=              PM ROUTINE=               FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=       75.0 FLW= 27573. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=        CTR=         EFF=        CRF=
SO2 EMISSIONS
   UNC=        CTR=         EFF=        CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    10
---------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------

EQUP         1051134.            0.             0.             0.         1051134.
INST          951692.            0.             0.             0.          951692.
TD           2002826.            0.             0.             0.         2002826.
IND           653711.            0.             0.             0.          653711.
TDI          2656537.            0.             0.             0.         2656537.
CONT          531307.            0.             0.             0.          531307.
TK           3187844.            0.             0.             0.         3187844.
LAND            2000.            0.             0.             0.            2000.




WC            189693.            0.             0.             0.          189693.
TOTL         3379536.            0.             0.             0.         3379536.

DL            110903.            0.             0.             0.          110903.
SPRV          125519.            0.             0.             0.          125519.
MANT          117640.            0.             0.             0.          117640.
SP             85724.            0.             0.             0.           85724.
ELEC              0.             0.             0.             0.              0.
UC             53069.            0.             0.             0.           53069.
WTR               0.             0.             0.             0.              0.
SW             28178.            0.             0.             0.           28178.
SLDG              0.             0.             0.             0.              0.
LW                0.             0.             0.             0.              0.
SC                0.             0.             0.             0.              0.
LMS               0.             0.             0.             0.              0.
LIME              0.             0.             0.             0.              0.
NH3               0.             0.             0.             0.              0.
LYE               0.             0.             0.             0.              0.
FUEL          713502.            0.             0.             0.          713502.
TDOM         1234535.            0.             0.             0.         1234535.
OH            147615.            0.             0.             0.          147615.
TOTL         1382150.            0.             0.             0.         1382150.

CR            419202.            0.             0.             0.          419202.
WCC            18969.            0.             0.             0.           18969.
MISC          127514.            0.             0.             0.          127514.
TCC           565685.            0.             0.             0.          565685.
TOTL         1947834.            0.             0.             0.         1947834.
```

HSC-75-Unc, SM

```
MODEL BOILER  11                              4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                PM ROUTINE= SM          FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      75.0 FLW= 27573. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=    1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.400 EFF=  39.10 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=         EFF=         CRF-
COST RATES
   ELEC- 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80




COST SUMMARY TABLE - RUN NO.    11
---------------------------------------------------------------------------------
ITEM           BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------

EQUP          1051134.              0.             0.          70899.       1122033.
INST           951692.              0.             0.             0.         951692.
TD            2002826.              0.             0.          70899.       2073725.
IND            653711.              0.             0.          23633.        677344.
TDI           2656537.              0.             0.          94532.       2751069.
CONT           531307.              0.             0.          18906.        550214.
TK            3187844.              0.             0.         113439.       3301282.
LAND             2000.              0.             0.             0.           2000.
WC             189693.              0.             0.           4890.        194582.
TOTL          3379536.              0.             0.         118328.       3497864.

DL             110903.              0.             0.           6788.        117690.
SPRV           125519.              0.             0.           1018.        126538.
MANT           117640.              0.             0.           5789.        123428.
SP              85724.              0.             0.            473.         86197.
ELEC               0.               0.             0.           4732.          4732.
UC              53069.              0.             0.             0.          53069.
WTR                0.               0.             0.             0.              0.
SW              28178.              0.             0.            760.         28938.
SLDG               0.               0.             0.             0.              0.
LW                 0.               0.             0.             0.              0.
SC                 0.               0.             0.             0.              0.
LMS                0.               0.             0.             0.              0.
LIME               0.               0.             0.             0.              0.
NH3                0.               0.             0.             0.              0.
LYE                0.               0.             0.             0.              0.
FUEL           713502.              0.             0.             0.         713502.
TDOM          1234535.              0.             0.          19558.       1254093.
OM             147615.              0.             0.           5694.        153309.
TOTL          1382150.              0.             0.          25252.       1407401.

CR             419202.              0.             0.          14917.        434119.
WCC             18969.              0.             0.            489.         19458.
MISC           127514.              0.             0.           4538.        132051.
TCC            565685.              0.             0.          19944.        585628.
TOTL          1947834.              0.             0.          45196.       1993029.
```

HSC-75-Unc, SSS

```
MODEL BOILER  12                              4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=               PM ROUTINE= SSS          FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      75.0 FLW= 27573. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.200 EFF=  69.60 CRF= 0.1313
SO2 EMISSIONS
   UNC=         CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    12
---------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------

EQUP        1051134.             0.             0.          128875.      1180009.
INST         951692.             0.             0.              0.        951692.
TD          2002826.             0.             0.          128875.      2131701.
IND          653711.             0.             0.           42958.       696670.
TDI         2656537.             0.             0.          171834.      2828370.
CONT         531307.             0.             0.           34367.       565674.
TK          3187844.             0.             0.          206200.      3394044.
LAND           2000.             0.             0.              0.          2000.
WC           189693.             0.             0.            7546.       197239.
TOTL        3379536.             0.             0.          213746.      3593282.

DL           110903.             0.             0.            9502.       120405.
SPRV         125519.             0.             0.            1425.       126945.
MANT         117640.             0.             0.            9586.       127226.
SP            85724.             0.             0.             859.        86584.
ELEC             0.              0.             0.            7460.         7460.
UC            53069.             0.             0.              0.         53069.
WTR              0.              0.             0.              0.             0.
SW            28178.             0.             0.            1351.        29529.
SLDG             0.              0.             0.              0.             0.
LW               0.              0.             0.              0.             0.
SC               0.              0.             0.              0.             0.
LMS              0.              0.             0.              0.             0.
LIME             0.              0.             0.              0.             0.
NH3              0.              0.             0.              0.             0.



LYE              0.              0.             0.              0.             0.
FUEL         713502.             0.             0.              0.        713502.
TDOM        1234535.             0.             0.           30184.      1264719.
OH           147615.             0.             0.            8408.       156023.
TOTL        1382150.             0.             0.           38592.      1420741.

CR           419202.             0.             0.           27115.       446317.
WCC           18969.             0.             0.             755.        19724.
MISC         127514.             0.             0.            8248.       135762.
TCC          565685.             0.             0.           36118.       601802.
TOTL        1947834.             0.             0.           74710.      2022543.
```

HSC-75-Unc, VS

```
MODEL BOILER  13                               4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                  PM ROUTINE= VS            FLOW FLAG=     1

BOILER SPECIFICATIONS
   Q=      75.0 FLW= 27573. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.100 EFF=  84.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=         EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    13
------------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
------------------------------------------------------------------------------------

EQUP        1051134.              0.             0.          90169.      1141302.
INST         951692.              0.             0.          59482.      1011175.
TD          2002826.              0.             0.         149651.      2152477.
IND          653711.              0.             0.          50895.       704606.
TDI         2656537.              0.             0.         200546.      2857082.
CONT         531307.              0.             0.          40109.       571416.
TK          3187844.              0.             0.         240655.      3428498.
LAND           2000.              0.             0.              0.         2000.
WC           189693.              0.             0.          11260.       200953.
TOTL        3379536.              0.             0.         251915.      3631450.




DL           110903.              0.             0.          13575.       124478.
SPRV         125519.              0.             0.              0.       125519.
MANT         117640.              0.             0.          12355.       129994.
SP            85724.              0.             0.              0.        85724.
ELEC              0.              0.             0.              0.            0.
UC            53069.              0.             0.          17463.        70532.
WTR               0.              0.             0.              0.            0.
SW            28178.              0.             0.           1647.        29825.
SLDG              0.              0.             0.              0.            0.
LW                0.              0.             0.              0.            0.
SC                0.              0.             0.              0.            0.
LMS               0.              0.             0.              0.            0.
LIME              0.              0.             0.              0.            0.
NH3               0.              0.             0.              0.            0.
LYE               0.              0.             0.              0.            0.
FUEL         713502.              0.             0.              0.       713502.
TDOM        1234535.              0.             0.          45039.      1279574.
OH           147615.              0.             0.          10814.       158429.
TOTL        1382150.              0.             0.          55854.      1438003.

CR           419202.              0.             0.          31646.       450848.
WCC           18969.              0.             0.           1126.        20095.
MISC         127514.              0.             0.           9626.       137140.
TCC          565685.              0.             0.          42398.       608083.
TOTL        1947834.              0.             0.          98252.      2046085.
```

HSC-75-Unc, ESP

```
MODEL BOILER  14                                4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                 PM ROUTINE= ESPC         FLOW FLAG=    1

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =    117.3
TOTAL PLATE AREA (SQ FT) =      3233.3
BOILER SPECIFICATIONS
   Q=        75.0 FLW= 27573. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.050 EFF=  92.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=          CTR=          EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80




COST SUMMARY TABLE - RUN NO.    14
------------------------------------------------------------------------------------
ITEM         BOILER        NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
------------------------------------------------------------------------------------

EQUP        1051134.            0.             0.          114921.       1166054.
INST         951692.            0.             0.          134457.       1086149.
TD          2002826.            0.             0.          249377.       2252203.
IND          653711.            0.             0.           83292.        737003.
TDI         2656537.            0.             0.          332669.       2989206.
CONT         531307.            0.             0.           66534.        597841.
TK          3187844.            0.             0.          399203.       3587047.
LAND           2000.            0.             0.               0.          2000.
WC           189693.            0.             0.            7553.        197246.
TOTL        3379536.            0.             0.          406757.       3786292.

DL           110903.            0.             0.           13575.        124478.
SPRV         125519.            0.             0.               0.        125519.
MANT         117640.            0.             0.           11577.        129217.
SP            85724.            0.             0.            1836.         87561.
ELEC              0.            0.             0.               0.             0.
UC            53069.            0.             0.            1430.         54500.
WTR               0.            0.             0.               0.             0.
SW            28178.            0.             0.            1795.         29973.
SLDG              0.            0.             0.               0.             0.
LW                0.            0.             0.               0.             0.
SC                0.            0.             0.               0.             0.
LMS               0.            0.             0.               0.             0.
LIME              0.            0.             0.               0.             0.
NH3               0.            0.             0.               0.             0.
LYE               0.            0.             0.               0.             0.
FUEL         713502.            0.             0.               0.        713502.
TDOM        1234535.            0.             0.           30213.       1264748.
OH           147615.            0.             0.           11090.        158705.
TOTL        1382150.            0.             0.           41303.       1423452.

CR           419202.            0.             0.           52495.        471697.
WCC           18969.            0.             0.             755.         19725.
MISC         127514.            0.             0.           15968.        143482.
TCC          565685.            0.             0.           69219.        634903.
TOTL        1947834.            0.             0.          110521.       2058355.
```

HSC-75-DA(50), DA/PM

```
MODEL BOILER  15                               4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DAC          PM ROUTINE=              FLOW FLAG=    1

S STAR (METRIC)=      0.645
S DSTAR (METRIC)=    51.023
P DSTAR (METRIC)=    20.034
BOILER SPECIFICATIONS
   Q=      75.0 FLW= 27573. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.100 EFF=  84.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  2.850 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    15
--------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
--------------------------------------------------------------------------------

EQUP        1051134.              0.              0.            0.       1051134.
INST         951692.              0.              0.            0.        951692.
TD          2002826.              0.         693867.            0.       2696692.
IND          653711.              0.              0.            0.        653711.
TDI         2656537.              0.              0.            0.       2656537.
CONT         531307.              0.              0.            0.        531307.
TK          3187844.              0.        1120522.            0.       4308366.
LAND           2000.              0.              0.            0.          2000.
WC           189693.              0.          62005.            0.        251698.
TOTL        3379536.              0.        1182527.            0.       4562063.

DL           110903.              0.         105000.            0.        215903.
SPRV         125519.              0.          21000.            0.        146519.
MANT         117640.              0.          55509.            0.        173149.
SP            85724.              0.              0.            0.         85724.
ELEC              0.              0.          10126.            0.         10126.
UC            53069.              0.              0.            0.         53069.
WTR               0.              0.            563.            0.           563.
SW            28178.              0.              0.            0.         28178.
SLDG              0.              0.          35695.            0.         35695.
LW                0.              0.              0.            0.             0.




SC                0.              0.           3658.            0.          3658.
LMS               0.              0.              0.            0.             0.
LIME              0.              0.          16470.            0.         16470.
NH3               0.              0.              0.            0.             0.
LYE               0.              0.              0.            0.             0.
FUEL         713502.              0.              0.            0.        713502.
TDOM        1234535.              0.         248021.            0.       1482556.
OH           147615.              0.          78692.            0.        226308.
TOTL        1382150.              0.         326714.            0.       1708863.

CR           419202.              0.         147349.            0.        566550.
WCC           18969.              0.           6201.            0.         25170.
MISC         127514.              0.          44821.            0.        172335.
TCC          565685.              0.         198370.            0.        764055.
TOTL        1947834.              0.         525084.            0.       2472917.
```

HSC-75-DA(50), ESP

```
MODEL BOILER  16                               4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DA              PM ROUTINE= ESPC          FLOW FLAG=    1

S STAR (METRIC)=     0.645
S DSTAR (METRIC)=    51.023

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =    117.3
TOTAL PLATE AREA (SQ FT) =      3233.3
BOILER SPECIFICATIONS
   Q=      75.0 FLW= 27573. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.050 EFF=  92.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  2.850 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    16
-------------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
-------------------------------------------------------------------------------------

EQUP         1051134.             0.             0.         114921.       1166054.




INST          951692.             0.             0.         134457.       1086149.
TD           2002826.             0.        601476.         249377.       2853678.
IND           653711.             0.             0.          83292.        737003.
TDI          2656537.             0.             0.         332669.       2989206.
CONT          531307.             0.             0.          66534.        597841.
TK           3187844.             0.        983784.         399203.       4570830.
LAND            2000.             0.             0.              0.          2000.
WC            189693.             0.         58409.           7553.        255655.
TOTL         3379536.             0.       1042193.         406757.       4828185.

DL            110903.             0.        105000.          13575.        229478.
SPRV          125519.             0.         21000.              0.        146519.
MANT          117640.             0.         48118.          11577.        177335.
SP             85724.             0.             0.           1836.         87561.
ELEC              0.              0.          4872.              0.          4872.
UC             53069.             0.             0.           1430.         54500.
WTR               0.              0.           563.              0.           563.
SW             28178.             0.             0.           1795.         29973.
SLDG              0.              0.         33955.              0.         33955.
LW                0.              0.             0.              0.             0.
SC                0.              0.          3658.              0.          3658.
LMS               0.              0.             0.              0.             0.
LIME              0.              0.         16470.              0.         16470.
NH3               0.              0.             0.              0.             0.
LYE               0.              0.             0.              0.             0.
FUEL          713502.             0.             0.              0.        713502.
TDOM         1234535.             0.        233637.          30213.       1498385.
OH            147615.             0.         76771.          11090.        235475.
TOTL         1382150.             0.        310408.          41303.       1733859.

CR            419202.             0.        129368.          52495.        601064.
WCC            18969.             0.          5841.            755.         25566.
MISC          127514.             0.         39351.          15968.        182833.
TCC           565685.             0.        174560.          69219.        809463.
TOTL         1947834.             0.        484968.         110521.       2543322.
```

HSC-75-DA(90), DA/PM

```
MODEL BOILER  17                                   4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DAC          PM ROUTINE=              FLOW FLAG=    1

S STAR (METRIC)=     1.161
S DSTAR (METRIC)=    91.842




P DSTAR (METRIC)=    20.034
BOILER SPECIFICATIONS
   Q=       75.0 FLW= 27573. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.100 EFF=  84.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  0.570 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    17
------------------------------------------------------------------------------------
ITEM          BOILER       NOX CONTROL   SO2 CONTROL     PM CONTROL          TOTAL
------------------------------------------------------------------------------------

EQUP        1051134.              0.              0.              0.        1051134.
INST         951692.              0.              0.              0.         951692.
TD          2002826.              0.         775111.              0.        2777937.
IND          653711.              0.              0.              0.         653711.
TDI         2656537.              0.              0.              0.        2656537.
CONT         531307.              0.              0.              0.         531307.
TK          3187844.              0.        1240764.              0.        4428608.
LAND           2000.              0.              0.              0.           2000.
WC           189693.              0.          74746.              0.         264439.
TOTL        3379536.              0.        1315510.              0.        4695046.

DL           110903.              0.         105000.              0.         215903.
SPRV         125519.              0.          21000.              0.         146519.
MANT         117640.              0.          62009.              0.         179648.
SP            85724.              0.              0.              0.          85724.
ELEC              0.              0.          10799.              0.          10799.
UC            53069.              0.              0.              0.          53069.
WTR               0.              0.            605.              0.            605.
SW            28178.              0.              0.              0.          28178.
SLDG              0.              0.          63091.              0.          63091.
LW                0.              0.              0.              0.              0.
SC                0.              0.           6697.              0.           6697.
LMS               0.              0.              0.              0.              0.
LIME              0.              0.          29785.              0.          29785.
NH3               0.              0.              0.              0.              0.
LYE               0.              0.              0.              0.              0.
FUEL         713502.              0.              0.              0.         713502.
TDOM        1234535.              0.         298986.              0.        1533520.



OH           147615.              0.          80382.              0.         227997.
TOTL        1382150.              0.         379368.              0.        1761517.

CR           419202.              0.         163160.              0.         582362.
WCC           18969.              0.           7475.              0.          26444.
MISC         127514.              0.          49631.              0.         177144.
TCC          565685.              0.         220266.              0.         785950.
TOTL        1947834.              0.         599633.              0.        2547467.
```

HSC-75-DA(90), ESP

```
MODEL BOILER  18                                 4-01-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DA              PM ROUTINE= ESPC          FLOW FLAG=    1

S STAR (METRIC)=      1.161
S DSTAR (METRIC)=    91.842

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =     117.3
TOTAL PLATE AREA (SQ FT) =      3233.3
BOILER SPECIFICATIONS
   Q=       75.0 FLW= 27573. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   0.657 CTR=  0.050 EFF=  92.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  0.570 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    18
--------------------------------------------------------------------------------------------
ITEM           BOILER           NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
--------------------------------------------------------------------------------------------

EQUP         1051134.              0.              0.           114921.        1166054.
INST          951692.              0.              0.           134457.        1086149.
TD           2002826.              0.         700727.           249377.        2952930.
IND           653711.              0.              0.            83292.         737003.
TDI          2656537.              0.              0.           332669.        2989206.
CONT          531307.              0.              0.            66534.         597841.
TK           3187844.              0.        1130676.           399203.        4717723.
LAND            2000.              0.              0.                0.           2000.




WC            189693.              0.          71423.             7553.         268669.
TOTL         3379536.              0.        1202099.           406757.        4988391.

DL            110903.              0.         105000.            13575.         229478.
SPRV          125519.              0.          21000.                0.         146519.
MANT          117640.              0.          56058.            11577.         185275.
SP             85724.              0.              0.             1836.          87561.
ELEC               0.              0.           5196.                0.           5196.
UC             53069.              0.              0.             1430.          54500.
WTR                0.              0.            605.                0.            605.
SW             28178.              0.              0.             1795.          29973.
SLDG               0.              0.          61351.                0.          61351.
LW                 0.              0.              0.                0.              0.
SC                 0.              0.           6697.                0.           6697.
LMS                0.              0.              0.                0.              0.
LIME               0.              0.          29785.                0.          29785.
NH3                0.              0.              0.                0.              0.
LYE                0.              0.              0.                0.              0.
FUEL          713502.              0.              0.                0.         713502.
TDOM         1234535.              0.         285693.            30213.        1550440.
OH            147615.              0.          78835.            11090.         237540.
TOTL         1382150.              0.         364528.            41303.        1787979.

CR            419202.              0.         148684.            52495.         620381.
WCC            18969.              0.           7142.              755.          26867.
MISC          127514.              0.          45227.            15968.         188709.
TCC           565685.              0.         201053.            69219.         835956.
TOTL         1947834.              0.         565581.           110521.        2623935.
```

HSC-150-Unc, Unc

```
MODEL BOILER  19                                     4-01-82
BOILER ROUTINE SPRD    SO2 ROUTINE=                       PM ROUTINE=                    FLOW FLAG=    1
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 55146. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=          CTR=          EFF=          CRF=
SO2 EMISSIONS
   UNC=          CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
```

```
COST SUMMARY TABLE - RUN NO.    19
----------------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL      SO2 CONTROL      PM CONTROL        TOTAL
----------------------------------------------------------------------------------------

EQUP        2542138.              0.               0.               0.          2542138.
INST        2165530.              0.               0.               0.          2165530.
TD          4707668.              0.               0.               0.          4707668.
IND         1515863.              0.               0.               0.          1515863.
TDI         6223531.              0.               0.               0.          6223531.
CONT        1244706.              0.               0.               0.          1244706.
TK          7468237.              0.               0.               0.          7468237.
LAND           2000.              0.               0.               0.             2000.
WC           266406.              0.               0.               0.           266406.
TOTL        7736643.              0.               0.               0.          7736643.

DL           186128.              0.               0.               0.           186128.
SPRV          78752.              0.               0.               0.            78752.
MANT          85796.              0.               0.               0.            85796.
SF           153400.              0.               0.               0.           153400.
ELEC              0.              0.               0.               0.                0.
UC            69844.              0.               0.               0.            69844.
WTR               0.              0.               0.               0.                0.
SW            16229.              0.               0.               0.            16229.
SLDG              0.              0.               0.               0.                0.
LW                0.              0.               0.               0.                0.
SC                0.              0.               0.               0.                0.
LMS               0.              0.               0.               0.                0.
LIME              0.              0.               0.               0.                0.
NH3               0.              0.               0.               0.                0.
LYE               0.              0.               0.               0.                0.
FUEL        1427004.              0.               0.               0.          1427004.
TDOM        2017152.              0.               0.               0.          2017152.
OH           186898.              0.               0.               0.           186898.
TOTL        2204049.              0.               0.               0.          2204049.

CR           982073.              0.               0.               0.           982073.
WCC           26641.              0.               0.               0.            26641.
MISC         298729.              0.               0.               0.           298729.
TCC         1307443.              0.               0.               0.          1307443.
TOTL        3511492.              0.               0.               0.          3511492.
```

HSC-150-Unc, SM

```
MODEL BOILER  20                           4-01-82
BOILER ROUTINE SPRD    SO2 ROUTINE=             PM ROUTINE= SM           FLOW FLAG=    1
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 55146. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   2.540 CTR=  0.600 EFF=  76.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=         EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    20
--------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP        2542138.             0.             0.        119387.       2661524.
INST        2165530.             0.             0.             0.       2165530.
TD          4707668.             0.             0.        119387.       4827054.
IND         1515863.             0.             0.         39796.       1555658.
TDI         6223531.             0.             0.        159183.       6382713.
CONT        1244706.             0.             0.         31836.       1276542.
TK          7468237.             0.             0.        191019.       7659255.
LAND           2000.             0.             0.             0.          2000.
WC           266406.             0.             0.          9856.        276262.
TOTL        7736643.             0.             0.        200875.       7937517.

DL           186128.             0.             0.          9769.        195897.
SPRV          78752.             0.             0.          1465.         80217.
MANT          85796.             0.             0.          6459.         92255.
SF           153400.             0.             0.           796.        154196.
ELEC              0.             0.             0.          9463.          9463.
UC            69844.             0.             0.             0.         69844.
WTR               0.             0.             0.             0.             0.
SW            16229.             0.             0.         11471.         27700.
SLDG              0.             0.             0.             0.             0.
LW                0.             0.             0.             0.             0.
SC                0.             0.             0.             0.             0.
LMS               0.             0.             0.             0.             0.
LIME              0.             0.             0.             0.             0.
NH3               0.             0.             0.             0.             0.




LYE               0.             0.             0.             0.             0.
FUEL        1427004.             0.             0.             0.       1427004.
TDOM        2017152.             0.             0.         39424.       2056575.
OH           186898.             0.             0.          7738.        194636.
TOTL        2204049.             0.             0.         47162.       2251210.

CR           982073.             0.             0.         25119.       1007192.
WCC           26641.             0.             0.           986.         27626.
MISC         298729.             0.             0.          7641.        306370.
TCC         1307443.             0.             0.         33745.       1341188.
TOTL        3511492.             0.             0.         80907.       3592398.
```

HSC-150-Unc, SSS

```
MODEL BOILER  21                          4-01-82
BOILER ROUTINE SPRD    SO2 ROUTINE=               PM ROUTINE= SSS          FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=     150.0 FLW= 55146. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   2.540 CTR=  0.200 EFF=  92.10 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=        EFF=        CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    21
---------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------

EQUP        2542138.              0.             0.          222357.      2764494.
INST        2165530.              0.             0.              0.       2165530.
TD          4707668.              0.             0.          222357.      4930024.
IND         1515863.              0.             0.           74119.      1589981.
TDI         6223531.              0.             0.          296476.      6520006.
CONT        1244706.              0.             0.           59295.      1304001.
TK          7468237.              0.             0.          355771.      7824007.
LAND           2000.              0.             0.              0.          2000.
WC           266406.              0.             0.           14447.       280854.
TOTL        7736643.              0.             0.          370218.      8106860.




DL           186128.              0.             0.           13676.       199804.
SPRV          78752.              0.             0.            2051.        80803.
MANT          85796.              0.             0.           11998.        97794.
SP           153400.              0.             0.            1482.       154882.
ELEC             0.               0.             0.           14745.        14745.
UC            69844.              0.             0.              0.         69844.
WTR              0.               0.             0.              0.             0.
SW            16229.              0.             0.           13836.        30065.
SLDG             0.               0.             0.              0.             0.
LW               0.               0.             0.              0.             0.
SC               0.               0.             0.              0.             0.
LMS              0.               0.             0.              0.             0.
LIME             0.               0.             0.              0.             0.
NH3              0.               0.             0.              0.             0.
LYE              0.               0.             0.              0.             0.
FUEL        1427004.              0.             0.              0.       1427004.
TDOM        2017152.              0.             0.           57789.      2074941.
OH           186898.              0.             0.           11697.       198595.
TOTL        2204049.              0.             0.           69486.      2273535.

CR           982073.              0.             0.           46784.      1028857.
WCC           26641.              0.             0.            1445.        28085.
MISC         298729.              0.             0.           14231.       312960.
TCC         1307443.              0.             0.           62459.      1369902.
TOTL        3511492.              0.             0.          131946.      3643437.
```

HSC-150-Unc, VS

```
MODEL BOILER  22                                4-01-82
BOILER ROUTINE SPRD    SO2 ROUTINE=                 PM ROUTINE= VS            FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      150.0 FLW= 55146. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   2.540 CTR=  0.100 EFF=  96.10 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=          EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    22
-------------------------------------------------------------------------------




ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
-------------------------------------------------------------------------------

EQUP        2542138.               0.             0.         153422.      2695559.
INST        2165530.               0.             0.         105061.      2270590.
TD          4707668.               0.             0.         258483.      4966150.
IND         1515863.               0.             0.          86326.      1602189.
TDI         6223531.               0.             0.         344809.      6568339.
CONT        1244706.               0.             0.          68962.      1313667.
TK          7468237.               0.             0.         413770.      7882007.
LAND           2000.               0.             0.              0.         2000.
WC           266406.               0.             0.          21902.       288308.
TOTL        7736643.               0.             0.         435672.      8172315.

DL           186128.               0.             0.          19538.       205665.
SPRV          78752.               0.             0.              0.        78752.
MANT          85796.               0.             0.          20185.       105981.
SP           153400.               0.             0.              0.       153400.
ELEC              0.               0.             0.              0.            0.
UC            69844.               0.             0.          33456.       103301.
WTR               0.               0.             0.              0.            0.
SW            16229.               0.             0.          14428.        30657.
SLDG              0.               0.             0.              0.            0.
LW                0.               0.             0.              0.            0.
SC                0.               0.             0.              0.            0.
LMS               0.               0.             0.              0.            0.
LIME              0.               0.             0.              0.            0.
NH3               0.               0.             0.              0.            0.
LYE               0.               0.             0.              0.            0.
FUEL        1427004.               0.             0.              0.      1427004.
TDOM        2017152.               0.             0.          87606.      2104758.
OH           186898.               0.             0.          16189.       203087.
TOTL        2204049.               0.             0.         103795.      2307844.

CR           982073.               0.             0.          54411.      1036484.
WCC           26641.               0.             0.           2190.        28831.
MISC         298729.               0.             0.          16551.       315280.
TCC         1307443.               0.             0.          73152.      1380594.
TOTL        3511492.               0.             0.         176947.      3688439.
```

HSC-150-Unc, ESP

```
MODEL BOILER  23                                  4-01-82
BOILER ROUTINE SPRD    SO2 ROUTINE=                   PM ROUTINE= ESPC        FLOW FLAG=    1




SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =    189.3
TOTAL PLATE AREA (SQ FT) =    10440.7
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 55146. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   2.540 CTR=  0.050 EFF=  98.00 CRF= 0.1315
SO2 EMISSIONS
   UNC=          CTR=          EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    23
--------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP         2542138.           0.             0.          359167.      2901304.
INST         2165530.           0.             0.          395084.      2560613.
TD           4707668.           0.             0.          754250.      5461918.
IND          1515863.           0.             0.          251920.      1767782.
TDI          6223531.           0.             0.         1006170.      7229701.
CONT         1244706.           0.             0.          201234.      1445940.
TK           7468237.           0.             0.         1207404.      8675641.
LAND            2000.           0.             0.               0.         2000.
WC            266406.           0.             0.           14481.       280887.
TOTL         7736643.           0.             0.         1221884.      8958527.

DL            186128.           0.             0.           19538.       205665.
SPRV           78752.           0.             0.               0.        78752.
MANT           85796.           0.             0.           12919.        98715.
SP            153400.           0.             0.            5554.       158954.
ELEC               0.           0.             0.               0.            0.
UC             69844.           0.             0.            5190.        75034.
WTR                0.           0.             0.               0.            0.
SW             16229.           0.             0.           14723.        30952.
SLDG               0.           0.             0.               0.            0.
LW                 0.           0.             0.               0.            0.
SC                 0.           0.             0.               0.            0.
LMS                0.           0.             0.               0.            0.
LIME               0.           0.             0.               0.            0.
NH3                0.           0.             0.               0.            0.



LYE                0.           0.             0.               0.            0.
FUEL         1427004.           0.             0.               0.      1427004.
TDOM         2017152.           0.             0.           57923.      2075075.
OH            186898.           0.             0.           15744.       202642.
TOTL         2204049.           0.             0.           73667.      2277716.

CR            982073.           0.             0.          158774.      1140846.
WCC            26641.           0.             0.            1448.        28089.
MISC          298729.           0.             0.           48296.       347026.
TCC          1307443.           0.             0.          208518.      1515960.
TOTL         3511492.           0.             0.          282185.      3793677.
```

HSC-150-DA(50), DA/PM

```
MODEL BOILER  24                           4-01-82
BOILER ROUTINE SPRD    SO2 ROUTINE= DAC         PM ROUTINE=              FLOW FLAG=    1


S STAR (METRIC)=     0.645
S DSTAR (METRIC)=   102.047
P DSTAR (METRIC)=   193.938
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 55146. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   2.540 CTR=  0.100 EFF=  96.10 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  2.850 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    24
--------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP        2542138.            0.              0.             0.       2542138.
INST        2165530.            0.              0.             0.       2165530.
TD          4707668.            0.         958181.             0.       5665848.
IND         1515863.            0.              0.             0.       1515863.
TDI         6223531.            0.              0.             0.       6223531.
CONT        1244706.            0.              0.             0.       1244706.
TK          7468237.            0.        1511707.             0.       8979944.





LAND           2000.            0.              0.             0.          2000.
WC           266406.            0.          87509.             0.        353916.
TOTL        7736643.            0.        1599216.             0.       9335859.

DL           186128.            0.         105000.             0.        291128.
SPRV          78752.            0.          21000.             0.         99752.
MANT          85796.            0.          76654.             0.        162450.
SP           153400.            0.              0.             0.        153400.
ELEC              0.            0.          20252.             0.         20252.
UC            69844.            0.              0.             0.         69844.
WTR               0.            0.           1068.             0.          1068.
SW            16229.            0.              0.             0.         16229.
SLDG              0.            0.          85039.             0.         85039.
LW                0.            0.              0.             0.             0.
SC                0.            0.           7912.             0.          7912.
LMS               0.            0.              0.             0.             0.
LIME              0.            0.          33113.             0.         33113.
NH3               0.            0.              0.             0.             0.
LYE               0.            0.              0.             0.             0.
FUEL        1427004.            0.              0.             0.       1427004.
TDOM        2017152.            0.         350038.             0.       2367189.
OH           186898.            0.          84190.             0.        271088.
TOTL        2204049.            0.         434228.             0.       2638277.

CR           982073.            0.         198789.             0.       1180862.
WCC           26641.            0.           8751.             0.         35392.
MISC         298729.            0.          60468.             0.        359198.
TCC         1307443.            0.         268009.             0.       1575451.
TOTL        3511492.            0.         702237.             0.       4213728.
```

HSC-150-DA(50), ESP

```
MODEL BOILER  25                                4-01-82
BOILER ROUTINE SPRD    SO2 ROUTINE= DA            PM ROUTINE= ESPC          FLOW FLAG=    1


S STAR (METRIC)=     0.645
S DSTAR (METRIC)=   102.047

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =    189.3
TOTAL PLATE AREA (SQ FT) =    10440.7
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 55146. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS






   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   2.540 CTR=  0.050 EFF=  98.00 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  2.850 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SND=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    25
---------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------

EQUP          2542138.            0.             0.        359167.       2901304.
INST          2165530.            0.             0.        395084.       2560613.
TD            4707668.            0.        834849.        754250.       6296767.
IND           1515863.            0.             0.        251920.       1767782.
TDI           6223531.            0.             0.       1006170.       7229701.
CONT          1244706.            0.             0.        201234.       1445940.
TK            7468237.            0.       1329176.       1207404.      10004817.
LAND             2000.            0.             0.             0.          2000.
WC             266406.            0.         78206.         14481.        359094.
TOTL          7736643.            0.       1407382.       1221884.      10365909.

DL             186128.            0.        105000.         19538.        310665.
SPRV            78752.            0.         21000.             0.         99752.
MANT            85796.            0.         66788.         12919.        165503.
SP             153400.            0.             0.          5554.        158954.
ELEC                0.            0.          9745.             0.          9745.
UC              69844.            0.             0.          5190.         75034.
WTR                 0.            0.          1068.             0.          1068.
SW              16229.            0.             0.         14723.         30952.
SLDG                0.            0.         68201.             0.         68201.
LW                  0.            0.             0.             0.             0.
SC                  0.            0.          7912.             0.          7912.
LMS                 0.            0.             0.             0.             0.
LIME                0.            0.         33113.             0.         33113.
NH3                 0.            0.             0.             0.             0.
LYE                 0.            0.             0.             0.             0.
FUEL          1427004.            0.             0.             0.       1427004.
TDOM          2017152.            0.        312826.         57923.       2387900.
OH             186898.            0.         81625.         15744.        284267.
TOTL          2204049.            0.        394450.         73667.       2672166.

CR             982073.            0.        174787.        158774.       1315632.





WCC             26641.            0.          7821.          1448.         35909.
MISC           298729.            0.         53167.         48296.        400193.
TCC           1307443.            0.        235774.        208518.       1751734.
TOTL          3511492.            0.        630225.        282185.       4423901.
```

HSC-150-DA(90), DA/PM

```
MODEL BOILER  26                                4-01-82
BOILER ROUTINE SPRD    SO2 ROUTINE= DAC              PM ROUTINE=                FLOW FLAG=    1


S STAR (METRIC)=      1.161
S DSTAR (METRIC)=   183.684
P DSTAR (METRIC)=   193.938
BOILER SPECIFICATIONS
   Q=      150.0 FLW= 55146. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      1.81 H=   11800. S=      3.54 A=    10.58
PM EMISSIONS
   UNC=   2.540 CTR=  0.100 EFF=  96.10 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  0.570 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    26
---------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------

EQUP        2542138.             0.             0.             0.        2542138.
INST        2165530.             0.             0.             0.        2165530.
TD          4707668.             0.       1053447.             0.        5761115.
IND         1515863.             0.             0.             0.        1515863.
TDI         6223531.             0.             0.             0.        6223531.
CONT        1244706.             0.             0.             0.        1244706.
TK          7468237.             0.       1652701.             0.        9120938.
LAND           2000.             0.             0.             0.           2000.
WC           266406.             0.        111770.             0.         378176.
TOTL        7736643.             0.       1764470.             0.        9501113.

DL           186128.             0.        105000.             0.         291128.
SPRV          78752.             0.         21000.             0.          99752.
MANT          85796.             0.         84276.             0.         170072.




SP           153400.             0.             0.             0.         153400.
ELEC             0.              0.         21598.             0.          21598.
UC            69844.             0.             0.             0.          69844.
WTR              0.              0.          1147.             0.           1147.
SW            16229.             0.             0.             0.          16229.
SLDG             0.              0.        139832.             0.         139832.
LW               0.              0.             0.             0.              0.
SA               0.              0.         14485.             0.          14485.
LMS              0.              0.             0.             0.              0.
LIME             0.              0.         59741.             0.          59741.
NH3              0.              0.             0.             0.              0.
LYE              0.              0.             0.             0.              0.
FUEL        1427004.             0.             0.             0.        1427004.
TDOM        2017152.             0.        447079.             0.        2464231.
OH           186898.             0.         86172.             0.         273070.
TOTL        2204049.             0.        533251.             0.        2737299.

CR           982073.             0.        217330.             0.        1199403.
WCC           26641.             0.         11177.             0.          37818.
MISC         298729.             0.         66108.             0.         364837.
TCC         1307443.             0.        294615.             0.        1602058.
TOTL        3511492.             0.        827866.             0.        4339357.
```

HSC-150-DA(90), ESP

```
MODEL BOILER  27                                4-01-82
BOILER ROUTINE SPRD    SO2 ROUTINE= DA           PM ROUTINE= ESPC         FLOW FLAG=    1

S STAR (METRIC)=      1.161
S DSTAR (METRIC)=   183.684

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =    189.3
TOTAL PLATE AREA (SQ FT) =     10440.7
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 55146. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   2.540 CTR=  0.050 EFF=  98.00 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  0.570 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80




COST SUMMARY TABLE - RUN NO.    27
-----------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL     PM CONTROL      TOTAL
-----------------------------------------------------------------------------

EQUP        2542138.               0.             0.          359167.       2901304.
INST        2165530.               0.             0.          395084.       2560613.
TD          4707668.               0.        964908.          754250.       6426825.
IND         1515863.               0.             0.          251920.       1767782.
TDI         6223531.               0.             0.         1006170.       7229701.
CONT        1244706.               0.             0.          201234.       1445940.
TK          7468237.               0.       1521663.         1207404.      10197304.
LAND           2000.               0.             0.               0.          2000.
WC           266406.               0.        102988.           14481.        383875.
TOTL        7736643.               0.       1624650.         1221884.      10583177.

DL           186128.               0.        105000.           19538.        310665.
SPRV          78752.               0.         21000.               0.         99752.
MANT          85796.               0.         77193.           12919.        175907.
SP           153400.               0.             0.            5554.        158954.
ELEC              0.               0.         10393.               0.         10393.
UC            69844.               0.             0.            5190.         75034.
WTR               0.               0.          1147.               0.          1147.
SW            16229.               0.             0.           14723.         30952.
SLDG              0.               0.        122993.               0.        122993.
LW                0.               0.             0.               0.             0.
SC                0.               0.         14485.               0.         14485.
LMS               0.               0.             0.               0.             0.
LIME              0.               0.         59741.               0.         59741.
NH3               0.               0.             0.               0.             0.
LYE               0.               0.             0.               0.             0.
FUEL        1427004.               0.             0.               0.       1427004.
TDOM        2017152.               0.        411951.           57923.       2487026.
OH           186898.               0.         84330.           15744.        286972.
TOTL        2204049.               0.        496282.           73667.       2773997.

CR           982073.               0.        200099.          158774.       1340944.
WCC           26641.               0.         10299.            1448.         38388.
MISC         298729.               0.         60867.           48296.        407892.
TCC         1307443.               0.        271264.          208518.       1787223.
TOTL        3511492.               0.        767545.          282185.       4561222.
```

HSC-400-Unc, Unc

```
MODEL BOILER  28                                 4-01-82
BOILER ROUTINE PLVR    SO2 ROUTINE=                   PM ROUTINE=                FLOW FLAG=    3

BOILER SPECIFICATIONS
   Q=     400.0 FLW= 141646   CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=         CTR=          EFF=          CRF=
SO2 EMISSIONS
   UNC=         CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    28
---------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------

EQUP        7300607.             0.             0.             0.        7300607.
INST        3907605.             0.             0.             0.        3907605.
TD         11208212.             0.             0.             0.       11208212.
IND         3507363.             0.             0.             0.        3507363.
TDI        14715575.             0.             0.             0.       14715575.
CONT        2943114.             0.             0.             0.        2943114.
TK         17658688.             0.             0.             0.       17658688.
LAND           4000.             0.             0.             0.           4000.
WC           671217.             0.             0.             0.         671217.
TOTL       18333904.             0.             0.             0.       18333904.

DL           406848.             0.             0.             0.         406348.
SPRV         110674.             0.             0.             0.         110674.
MANT         215444.             0.             0.             0.         215444.
SP           262766.             0.             0.             0.         262766.
ELEC             0.              0.             0.             0.              0.
UC           396920.             0.             0.             0.         396920.
WTR              0.              0.             0.             0.              0.
SW            24274.             0.             0.             0.          24274.
SLDG             0.              0.             0.             0.              0.
LW               0.              0.             0.             0.              0.
SC               0.              0.             0.             0.              0.
LMS              0.              0.             0.             0.              0.
LIME             0.              0.             0.             0.              0.
NH3              0.              0.             0.             0.              0.




LYE              0.              0.             0.             0.              0.
FUEL        3805344.             0.             0.             0.        3805344.
TDOM        5222270.             0.             0.             0.        5222270.
OH           380945.             0.             0.             0.         380945.
TOTL        5603214.             0.             0.             0.        5603214.

CR          2322117.             0.             0.             0.        2322117.
WCC           67122.             0.             0.             0.          67122.
MISC         706348.             0.             0.             0.         706348.
TCC         3095585.             0.             0.             0.        3095585.
TOTL        8698799.             0.             0.             0.        8698799.
```

HSC-400-Unc, SM

```
MODEL BOILER  29                               4-01-82
BOILER ROUTINE PLVR    SO2 ROUTINE=                PM ROUTINE= SM           FLOW FLAG=    3

BOILER SPECIFICATIONS
   Q=     400.0 FLW= 141646    CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   3.810 CTR=  1.000 EFF=  73.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=         EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    29
-----------------------------------------------------------------------------------------
ITEM           BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
-----------------------------------------------------------------------------------------

EQUP          7300607.              0.              0.           242193.        7542799.
INST          3907605.              0.              0.               0.         3907605.
TD           11208212.              0.              0.           242193.       11450404.
IND           3507363.              0.              0.            80731.        3588093.
TDI          14715575.              0.              0.           322924.       15038498.
CONT          2943114.              0.              0.            64585.        3007698.
TK           17658688.              0.              0.           387509.       18046192.
LAND             4000.              0.              0.               0.            4000.
WC             671217.              0.              0.            26189.         697106.
TOTL         18333904.              0.              0.           413698.       18747600.




DL             406848.              0.              0.            19706.         426555.
SPRV           110674.              0.              0.             2956.         113630.
MANT           215444.              0.              0.            11925.         227369.
SP             262766.              0.              0.             1615.         264380.
ELEC                0.              0.              0.            24247.          24247.
UC             396920.              0.              0.                0.         396920.
WTR                 0.              0.              0.                0.              0.
SW              24274.              0.              0.            44308.          68582.
SLDG                0.              0.              0.                0.              0.
LW                  0.              0.              0.                0.              0.
SC                  0.              0.              0.                0.              0.
LMS                 0.              0.              0.                0.              0.
LIME                0.              0.              0.                0.              0.
NH3                 0.              0.              0.                0.              0.
LYE                 0.              0.              0.                0.              0.
FUEL          3805344.              0.              0.                0.        3805344.
TDOM          5222270.              0.              0.           104757.        5327026.
OH             380945.              0.              0.            15324.         396269.
TOTL          5603214.              0.              0.           120081.        5723295.

CR            2322117.              0.              0.            50957.        2373074.
WCC             67122.              0.              0.             2619.          69741.
MISC           706348.              0.              0.            15500.         721848.
TCC           3095585.              0.              0.            69077.        3164661.
TOTL          8698799.              0.              0.           189158.        8887956.
```

HSC-400-Unc, SSS

```
MODEL BOILER  30                           4-01-82
BOILER ROUTINE PLVR    SO2 ROUTINE=            PM ROUTINE= SSS         FLOW FLAG=    3

BOILER SPECIFICATIONS
   Q=     400.0 FLW=141646   CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800. S=     3.54 A=    10.58
PM EMISSIONS
   UNC=   3.810 CTR=  0.200 EFF=  94.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=         EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    30
-------------------------------------------------------------------------------



ITEM         BOILER         NOX CONTROL    SO2 CONTROL   PM CONTROL   TOTAL
-------------------------------------------------------------------------------

EQUP        7300607.             0.             0.       466227.       7766833.
INST        3907605.             0.             0.            0.       3907605.
TD         11208212.             0.             0.       466227.      11674438.
IND         3507363.             0.             0.       155409.       3662771.
TDI        14715575.             0.             0.       621636.      15337210.
CONT        2943114.             0.             0.       124327.       3067441.
TK         17658688.             0.             0.       745963.      18404640.
LAND           4000.             0.             0.            0.          4000.
WC           671217.             0.             0.        38295.        709512.
TOTL       18333904.             0.             0.       784258.      19118160.

DL           406848.             0.             0.        27589.        434437.
SPRV         110674.             0.             0.         4138.        114812.
MANT         215444.             0.             0.        24227.        239671.
SP           262766.             0.             0.         3108.        265874.
ELEC              0.             0.             0.        37195.         37195.
UC           396920.             0.             0.            0.        396920.
WTR               0.             0.             0.            0.             0.
SW            24274.             0.             0.        56922.         81197.
SLDG              0.             0.             0.            0.             0.
LW                0.             0.             0.            0.             0.
SC                0.             0.             0.            0.             0.
LMS               0.             0.             0.            0.             0.
LIME              0.             0.             0.            0.             0.
NH3               0.             0.             0.            0.             0.
LYE               0.             0.             0.            0.             0.
FUEL        3805344.             0.             0.            0.       3805344.
TDOM        5222270.             0.             0.       153180.       5375449.
OH           380945.             0.             0.        23633.        404578.
TOTL        5603214.             0.             0.       176813.       5780026.

CR          2322117.             0.             0.        98094.       2420211.
WCC           67122.             0.             0.         3829.         70951.
MISC         706348.             0.             0.        29839.        736186.
TCC         3095585.             0.             0.       131762.       3227347.
TOTL        8698799.             0.             0.       308575.       9007373.
```

HSC-400-Unc, VS

```
MODEL BOILER  31                                  4-01-82
BOILER ROUTINE PLVR     SO2 ROUTINE=                   PM ROUTINE= VS            FLOW FLAG=    3




BOILER SPECIFICATIONS
   Q=      400.0 FLW= 141646    CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      1.81 H=    11800. S=      3.54 A=     10.58
PM EMISSIONS
   UNC=   3.810 CTR=  0.100 EFF=  97.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=          CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    31
----------------------------------------------------------------------------------
ITEM           BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
----------------------------------------------------------------------------------

EQUP          7300607.             0.             0.          351059.       7651665.
INST          3907605.             0.             0.          247473.       4155078.
TD           11208212.             0.             0.          598532.      11806743.
IND           3507363.             0.             0.          197034.       3704396.
TDI          14715575.             0.             0.          795566.      15511140.
CONT          2943114.             0.             0.          159113.       3102227.
TK           17658688.             0.             0.          954679.      18613360.
LAND             4000.             0.             0.              0.          4000.
WC             671217.             0.             0.           57037.        728254.
TOTL         18333904.             0.             0.         1011716.      19345616.

DL             406848.             0.             0.           39413.        446261.
SPRV           110674.             0.             0.              0.        110674.
MANT           215444.             0.             0.           46285.        261729.
SP             262766.             0.             0.              0.        262766.
ELEC               0.              0.             0.              0.             0.
UC             396920.             0.             0.           83953.        480872.
WTR                0.              0.             0.              0.             0.
SW              24274.             0.             0.           58499.         82773.
SLDG               0.              0.             0.              0.             0.
LW                 0.              0.             0.              0.             0.
SC                 0.              0.             0.              0.             0.
LMS                0.              0.             0.              0.             0.
LIME               0.              0.             0.              0.             0.
NH3                0.              0.             0.              0.             0.
LYE                0.              0.             0.              0.             0.
FUEL          3805344.             0.             0.              0.       3805344.
TDOM          5222270.             0.             0.          228149.       5450419.




OH             380945.             0.             0.           34105.        415050.
TOTL          5603214.             0.             0.          262254.       5865468.

CR            2322117.             0.             0.          125540.       2447657.
WCC             67122.             0.             0.            5704.         72825.
MISC           706348.             0.             0.           38187.        744535.
TCC           3095585.             0.             0.          169431.       3265016.
TOTL          8698799.             0.             0.          431685.       9130484.
```

HSC-400-Unc, ESP

```
MODEL BOILER  32                                4-01-82
BOILER ROUTINE PLVR    SO2 ROUTINE=                PM ROUTINE= ESPC         FLOW FLAG=    3

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =    220.0
TOTAL PLATE AREA (SQ FT) =     31090.4
BOILER SPECIFICATIONS
   Q=      400.0 FLW= 141646   CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=    11800. S=      3.54 A=     10.58
PM EMISSIONS
   UNC=   3.810 CTR=  0.050 EFF=  98.70 CRF= 0.1315
SO2 EMISSIONS
   UNC=          CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    32
---------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------

EQUP        7300607.               0.             0.          495871.       7796477.
INST        3907605.               0.             0.          545458.       4453063.
TD         11208212.               0.             0.         1041329.      12249540.
IND         3507363.               0.             0.          347804.       3855166.
TDI        14715575.               0.             0.         1389132.      16104707.
CONT        2943114.               0.             0.          277826.       3220940.
TK         17658688.               0.             0.         1666958.      19325632.
LAND           4000.               0.             0.               0.          4000.
WC           671217.               0.             0.           36665.        707882.
TOTL       18333904.               0.             0.         1703623.      20037520.





DL           406848.               0.             0.           39413.        446261.
SPRV         110674.               0.             0.               0.        110674.
MANT         215444.               0.             0.           23850.        239294.
SP           262766.               0.             0.            7668.        270434.
ELEC              0.               0.             0.               0.             0.
UC           396920.               0.             0.           16442.        413362.
WTR               0.               0.             0.               0.             0.
SW            24274.               0.             0.           59288.         83562.
SLDG              0.               0.             0.               0.             0.
LW                0.               0.             0.               0.             0.
SC                0.               0.             0.               0.             0.
LMS               0.               0.             0.               0.             0.
LIME              0.               0.             0.               0.             0.
NH3               0.               0.             0.               0.             0.
LYE               0.               0.             0.               0.             0.
FUEL        3805344.               0.             0.               0.       3805344.
IDOM        5222270.               0.             0.          146660.       5368930.
OH           380945.               0.             0.           30266.        411211.
TOTL        5603214.               0.             0.          176926.       5780139.

CR          2322117.               0.             0.          219205.       2541321.
WCC           67122.               0.             0.            3667.         70788.
MISC         706348.               0.             0.           66678.        773026.
TCC         3095585.               0.             0.          289550.       3385134.
TOTL        8698799.               0.             0.          466476.       9165274.
```

HSC-400-DA(50), DA/PM

```
MODEL BOILER  33                                  4-01-82
BOILER ROUTINE PLVR    SO2 ROUTINE= DAC          PM ROUTINE=              FLOW FLAG=    3

S STAR (METRIC)=      0.645
S DSTAR (METRIC)=   272.124
P DSTAR (METRIC)=   793.911
BOILER SPECIFICATIONS
   Q=      400.0 FLW= 141646   CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      1.81 H=    11800. S=      3.54 A=    10.58
PM EMISSIONS
   UNC=    3.810 CTR=  0.100 EFF=  97.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=    5.700 CTR=  2.850 EFF=  50.00 CRF= 0.1315
COST RATES



   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    33
-------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
-------------------------------------------------------------------------------

EQUP         7300607.            0.             0.            0.        7300607.
INST         3907605.            0.             0.            0.        3907605.
TD          11208212.            0.        1500361.           0.       12708573.
IND          3507363.            0.             0.            0.        3507363.
TDI         14715575.            0.             0.            0.       14715575.
CONT         2943114.            0.             0.            0.        2943114.
TK          17658688.            0.        2350533.           0.       20009216.
LAND            4000.            0.             0.            0.           4000.
WC            671217.            0.         165409.           0.         836626.
TOTL        18333904.            0.        2515942.           0.       20849840.

DL            406848.            0.         105000.           0.         511848.
SPRV          110674.            0.          21000.           0.         131674.
MANT          215444.            0.         120029.           0.         335473.
SP            262766.            0.             0.            0.         262766.
ELEC              0.             0.          51890.           0.          51890.
UC            396920.            0.             0.            0.         396920.
WTR               0.             0.           2644.           0.           2644.
SW             24274.            0.             0.            0.          24274.
SLDG              0.             0.         251284.           0.         251284.
LW                0.             0.             0.            0.              0.
SC                0.             0.          21203.           0.          21203.
LMS               0.             0.             0.            0.              0.
LIME              0.             0.          88589.           0.          88589.
NH3               0.             0.             0.            0.              0.
LYE               0.             0.             0.            0.              0.
FUEL         3805344.            0.             0.            0.        3805344.
TDOM         5222270.            0.         661638.           0.        5883907.
OH            380945.            0.          95467.           0.         476412.
TOTL         5603214.            0.         757105.           0.        6360319.

CR           2322117.            0.         309095.           0.        2631212.
WCC            67122.            0.          16541.           0.          83663.
MISC          706348.            0.          94021.           0.         800369.
TCC          3095585.            0.         419657.           0.        3515242.
TOTL         8698799.            0.        1176762.           0.        9875561.
```

HSC-400-DA(50), ESP

```
MODEL BOILER  34                              4-01-82
BOILER ROUTINE PLVR     SO2 ROUTINE= DA            PM ROUTINE= ESPC          FLOW FLAG=    3

S STAR (METRIC)=      0.645
S DSTAR (METRIC)=   272.124

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =     220.0
TOTAL PLATE AREA (SQ FT) =       31090.4
BOILER SPECIFICATIONS
   Q=      400.0 FLW= 141646   CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      1.81 H=    11800. S=      3.54 A=     10.58
PM EMISSIONS
   UNC=   3.810 CTR=  0.050 EFF=  98.70 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  2.850 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    34
--------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
--------------------------------------------------------------------------------

EQUP         7300607.             0.             0.         495871.      7796477.
INST         3907605.             0.             0.         545458.      4453063.
TD          11208212.             0.       1325946.        1041329.     13575486.
IND          3507363.             0.             0.         347804.      3855166.
TDI         14715575.             0.             0.        1389132.     16104707.
CONT         2943114.             0.             0.         277826.      3220940.
TK          17658688.             0.       2092399.        1666958.     21418016.
LAND            4000.             0.             0.              0.         4000.
WC            671217.             0.        137958.          36665.       845839.
TOTL        18333904.             0.       2230356.        1703623.     22267872.

DL            406848.             0.        105000.          39413.       551261.
SPRV          110674.             0.         21000.              0.       131674.
MANT          215444.             0.        106076.          23850.       345370.
SP            262766.             0.             0.           7668.       270434.
ELEC              0.              0.         24968.              0.        24968.
UC            396920.             0.             0.          16442.       413362.
WTR               0.              0.          2644.              0.         2644.




SW             24274.             0.             0.          59288.        83562.
SLDG              0.              0.        182351.              0.       182351.
LW                0.              0.             0.              0.            0.
SC                0.              0.         21203.              0.        21203.
LMS               0.              0.             0.              0.            0.
LIME              0.              0.         88589.              0.        88589.
NH3               0.              0.             0.              0.            0.
LYE               0.              0.             0.              0.            0.
FUEL         3805344.             0.             0.              0.      3805344.
TDOM         5222270.             0.        551830.         146660.      5920760.
OH            380945.             0.         91840.          30266.       503050.
TOTL         5603214.             0.        643670.         176926.      6423808.

CR           2322117.             0.        275150.         219205.      2816471.
WCC            67122.             0.         13796.           3667.        84584.
MISC          706348.             0.         83696.          66678.       856722.
TCC          3095585.             0.        372642.         289550.      3757776.
TOTL         8698799.             0.       1016312.         466476.     10181585.
```

HSC-400-DA(90), DA/PM

```
MODEL BOILER  35                               4-01-82
BOILER ROUTINE PLVR    SO2 ROUTINE= DAC            PM ROUTINE=                 FLOW FLAG=    3

S STAR (METRIC)=      1.161
S DSTAR (METRIC)=   489.824
P DSTAR (METRIC)=   793.911
BOILER SPECIFICATIONS
   Q=      400.0 FLW= 141646  CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=   11800  S=     3.54 A=     10.58
PM EMISSIONS
   UNC=   3.810 CTR=  0.100 EFF=  97.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  0.570 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    35
--------------------------------------------------------------------------------
ITEM         BOILER        NOX CONTROL     SO2 CONTROL    PM CONTROL      TOTAL
--------------------------------------------------------------------------------




EQUP        7300607.            0.                0.            0.      7300607.
INST        3907605.            0.                0.            0.      3907605.
TD         11208212.            0.          1626037.            0.     12834249.
IND         3507363.            0.                0.            0.      3507363.
TDI        14715575.            0.                0.            0.     14715575.
CONT        2943114.            0.                0.            0.      2943114.
TK         17658688.            0.          2536534.            0.     20195216.
LAND           4000.            0.                0.            0.         4000.
WC           671217.            0.           227519.            0.       898736.
TOTL       18333904.            0.          2764053.            0.     21097952.

DL           406848.            0.           105000.            0.       511848.
SPRV         110674.            0.            21000.            0.       131674.
MANT         215444.            0.           130083.            0.       345527.
SP           262766.            0.                0.            0.       262766.
ELEC              0.            0.            55340.            0.        55340.
UC           396920.            0.                0.            0.       396920.
WTR               0.            0.             2839.            0.         2839.
SW            24274.            0.                0.            0.        24274.
SLDG              0.            0.           397397.            0.       397397.
LW                0.            0.                0.            0.            0.
SC                0.            0.            38820.            0.        38820.
LMS               0.            0.                0.            0.            0.
LIME              0.            0.           159597.            0.       159597.
NH3               0.            0.                0.            0.            0.
LYE               0.            0.                0.            0.            0.
FUEL        3805344.            0.                0.            0.      3805344.
TDOM        5222270.            0.           910076.            0.      6132346.
OH           380945.            0.            98082.            0.       479026.
TOTL        5603214.            0.          1008158.            0.      6611371.

CR          2322117.            0.           333554.            0.      2655671.
WCC           67122.            0.            22752.            0.        89874.
MISC         706348.            0.           101461.            0.       807809.
TCC         3095585.            0.           457767.            0.      3553352.
TOTL        8698799.            0.          1465925.            0.     10164724.
```

HSC-400-DA(90), ESP

```
MODEL BOILER  36                                    4-01-82
BOILER ROUTINE PLVR    SO2 ROUTINE= DA                 PM ROUTINE= ESPC          FLOW FLAG=    3

S STAR (METRIC)=      1.161



S DSTAR (METRIC)=   489.824

SPECIFIC COLLECTION AREA (SQ FT/1000 ACFM) =     220.0
TOTAL PLATE AREA (SQ FT) =     31090.4
BOILER SPECIFICATIONS
   Q=      400.0 FLW= 141646   CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     1.81 H=    11800  S=      3.54 A=     10.58
PM EMISSIONS
   UNC=   3.810 CTR=  0.050 EFF=  98.70 CRF= 0.1315
SO2 EMISSIONS
   UNC=   5.700 CTR=  0.570 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    36
-----------------------------------------------------------------------------------------
ITEM        BOILER           NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
-----------------------------------------------------------------------------------------

EQUP      7300607.              0.              0.          495871.       7796477.
INST      3907605.              0.              0.          545458.       4453063.
TD       11208212.              0.        1516610.         1041329.      13766150.
IND       3507363.              0.              0.          347804.       3855166.
TDI      14715575.              0.              0.         1389132.      16104707.
CONT      2943114.              0.              0.          277826.       3220940.
TK       17658688.              0.        2374582.         1666958.      21700208.
LAND         4000.              0.              0.               0.          4000.
WC         671217.              0.         200920.           36665.        908801.
TOTL     18333904.              0.        2575501.         1703623.      22613008.

DL         406848.              0.         105000.           39413.        551261.
SPRV       110674.              0.          21000.               0.        131674.
MANT       215444.              0.         121329.           23850.        360623.
SP         262766.              0.              0.            7668.        270434.
ELEC            0.              0.          26628.               0.         26628.
UC         396920.              0.              0.           16442.        413362.
WTR             0.              0.           2839.               0.          2839.
SW          24274.              0.              0.           59288.         83562.
SLDG            0.              0.         328464.               0.        328464.
LW              0.              0.              0.               0.             0.
SC              0.              0.          38820.               0.         38820.
LMS             0.              0.              0.               0.             0.
LIME            0.              0.         159597.               0.        159597.
NH3             0.              0.              0.               0.             0.




LYE             0.              0.              0.               0.             0.
FUEL      3805344.              0.              0.               0.       3805344.
TDOM      5222270.              0.         803678.          146660.       6172608.
OH         380945.              0.          95805.           30266.        507016.
TOTL      5603214.              0.         899484.          176926.       6679622.

CR        2322117.              0.         312258.          219205.       2853578.
WCC         67122.              0.          20092.            3667.         90880.
MISC       706348.              0.          94983.           66678.        868009.
TCC       3095585.              0.         427333.          289550.       3812466.
TOTL      8698799.              0.        1326816.          466476.      10492090.
```

LSC-30-Unc, Unc

```
MODEL BOILER   1                                 4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                  PM ROUTINE=                FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=       30.0 FLW= 11334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=     0.60 A=      5.40
PM EMISSIONS
   UNC=   0.0    CTR=  0.0    EFF=   0.0  CRF= 0.0
SO2 EMISSIONS
   UNC=   0.0    CTR=  0.0    EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     1
---------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
---------------------------------------------------------------------------------

EQUP         713439.              0.             0.             0.        713439.
INST         630975.              0.             0.             0.        630975.
TD          1344413.              0.             0.             0.       1344413.
IND          437820.              0.             0.             0.        437820.
TDI         1782233.              0.             0.             0.       1782233.
CONT         356447.              0.             0.             0.        356447.
TK          2138679.              0.             0.             0.       2138679.
LAND           2000.              0.             0.             0.          2000.
WC           103737.              0.             0.             0.        103737.
TOTL        2244416.              0.             0.             0.       2244416.

DL             90863.             0.             0.             0.         90863.
SPRV           44001.             0.             0.             0.         44001.
MANT           41173.             0.             0.             0.         41173.
SP             65485.             0.             0.             0.         65485.
ELEC              0.              0.             0.             0.             0.
UC             35718.             0.             0.             0.         35718.
WTR               0.              0.             0.             0.             0.
SW             11092.             0.             0.             0.         11092.
SLDG              0.              0.             0.             0.             0.




LW                0.              0.             0.             0.             0.
SC                0.              0.             0.             0.             0.
LMS               0.              0.             0.             0.             0.
LIME              0.              0.             0.             0.             0.
NH3               0.              0.             0.             0.             0.
LYE               0.              0.             0.             0.             0.
FUEL          380009.             0.             0.             0.        380009.
TDOM          668339.             0.             0.             0.        668339.
OH             90054.             0.             0.             0.         90054.
TOTL          758393.             0.             0.             0.        758393.

CR            281236.             0.             0.             0.        281236.
WCC            10374.             0.             0.             0.         10374.
MISC           85547.             0.             0.             0.         85547.
TCC           377157.             0.             0.             0.        377157.
TOTL         1135550.             0.             0.             0.       1135550.
```

LSC-30-Unc, SM

```
MODEL BOILER   2                                4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                 PM ROUTINE= SM           FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=    9600. S=     0.60 A=      5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.400 EFF=  50.00 CRF= 0.1315
SO2 EMISSIONS
   UNC=   0.0    CTR=  0.0   EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     2
--------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
--------------------------------------------------------------------------------

EQUP          713439.             0.             0.          36338.       749777.
INST          630975.             0.             0.              0.       630975.
TD           1344413.             0.             0.          36338.      1380751.
IND           437820.             0.             0.          12113.       449933.
TDI          1782233.             0.             0.          48451.      1830683.
CONT          356447.             0.             0.           9690.       366137.




TK           2133679.             0.             0.          58141.      2196820.
LAND            2000.             0.             0.              0.         2000.
WC            103737.             0.             0.           3504.       107242.
TOTL         2244416.             0.             0.          61646.      2306061.

DL             90863.             0.             0.           4999.        95862.
SPRV           44001.             0.             0.            750.        44751.
MANT           41173.             0.             0.           5601.        46773.
SP             65485.             0.             0.            242.        65727.
ELEC               0.             0.             0.           1945.         1945.
UC             35718.             0.             0.              0.        35718.
WTR                0.             0.             0.              0.            0.
SW             11092.             0.             0.            481.        11573.
SLDG               0.             0.             0.              0.            0.
LW                 0.             0.             0.              0.            0.
SC                 0.             0.             0.              0.            0.
LMS                0.             0.             0.              0.            0.
LIME               0.             0.             0.              0.            0.
NH3                0.             0.             0.              0.            0.
LYE                0.             0.             0.              0.            0.
FUEL          380009.             0.             0.              0.       380009.
TDOM          668339.             0.             0.          14018.       682357.
OH             90054.             0.             0.           4513.        94568.
TOTL          758393.             0.             0.          18531.       776925.

CR            281236.             0.             0.           7646.       288882.
WCC            10374.             0.             0.            350.        10724.
MISC           85547.             0.             0.           2326.        87873.
TCC           377157.             0.             0.          10322.       387479.
TOTL         1135550.             0.             0.          28853.      1164402.
```

LSC-30-Unc, SSS

```
MODEL BOILER   3                              4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                PM ROUTINE= SSS          FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.200 EFF=  75.20 CRF= 0.1315
SO2 EMISSIONS
   UNC=   0.0   CTR=  0.0   EFF=   0.0  CRF= 0.0



COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     3
-----------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL   SO2 CONTROL    PM CONTROL    TOTAL
-----------------------------------------------------------------------------

EQUP        713439.             0.            0.        64023.      777462.
INST        630975.             0.            0.            0.      630975.
TD         1344413.             0.            0.        64023.     1408436.
IND         437820.             0.            0.        21341.      459161.
TDI        1782233.             0.            0.        85364.     1867597.
CONT        356447.             0.            0.        17073.      373519.
TK         2138679.             0.            0.       102437.     2241116.
LAND          2000.             0.            0.            0.        2000.
WC          103737.             0.            0.         5190.      108927.
TOTL       2244416.             0.            0.       107627.     2352043.

DL           90863.             0.            0.         6998.       97861.
SPRV         44001.             0.            0.         1050.       45051.
MANT         41173.             0.            0.         8453.       49626.
SP           65485.             0.            0.          427.       65912.
ELEC             0.             0.            0.         3114.        3114.
UC           35718.             0.            0.            0.       35718.
WTR              0.             0.            0.            0.           0.
SW           11092.             0.            0.          718.       11809.
SLDG             0.             0.            0.            0.           0.
LW               0.             0.            0.            0.           0.
SC               0.             0.            0.            0.           0.
LMS              0.             0.            0.            0.           0.
LIME             0.             0.            0.            0.           0.
NH3              0.             0.            0.            0.           0.
LYE              0.             0.            0.            0.           0.
FUEL        380009.             0.            0.            0.      380009.
TDOM        668339.             0.            0.        20760.      689099.
OH           90054.             0.            0.         6501.       96555.
TOTL        758393.             0.            0.        27261.      785654.

CR          281236.             0.            0.        13470.      294707.
WCC          10374.             0.            0.          519.       10893.
MISC         85547.             0.            0.         4097.       89645.
TCC         377157.             0.            0.        18087.      395244.
TOTL       1135550.             0.            0.        45347.     1180897.
```

LSC-30-Unc, VS

```
MODEL BOILER   4                                  4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                   PM ROUTINE= VS            FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11334. CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=      0.60 A=      5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.100 EFF=  87.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=   0.0    CTR=  0.0    EFF=    0.0   CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=    8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     4
-----------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL       TOTAL
-----------------------------------------------------------------------------------

EQUP          713439.              0.             0.          52916.        766355.
INST          630975.              0.             0.          32639.        663613.
TD           1344413.              0.             0.          85554.       1429967.
IND           437820.              0.             0.          30027.        467847.
TDI          1782233.              0.             0.         115581.       1897814.
CONT          356447.              0.             0.          23116.        379563.
TK           2138679.              0.             0.         138697.       2277376.
LAND            2000.              0.             0.              0.          2000.
WC            103737.              0.             0.           6471.        110208.
TOTL         2244416.              0.             0.         145168.       2389584.

DL             90863.              0.             0.           9998.        100860.
SPRV           44001.              0.             0.              0.         44001.
MANT           41173.              0.             0.           7657.         48830.
SP             65485.              0.             0.              0.         65485.
ELEC               0.              0.             0.              0.             0.
UC             35718.              0.             0.           7393.         43111.
WTR                0.              0.             0.              0.             0.
SW             11092.              0.             0.            836.         11928.
SLDG               0.              0.             0.              0.             0.
LW                 0.              0.             0.              0.             0.
SC                 0.              0.             0.              0.             0.
LMS                0.              0.             0.              0.             0.



LIME               0.              0.             0.              0.             0.
NH3                0.              0.             0.              0.             0.
LYE                0.              0.             0.              0.             0.
FUEL          380009.              0.             0.              0.        380009.
TDOM          668339.              0.             0.          25884.        694223.
OH             90054.              0.             0.           7589.         97644.
TOTL          758393.              0.             0.          33473.        791867.

CR            281236.              0.             0.          18239.        299475.
WCC            10374.              0.             0.            647.         11021.
MISC           85547.              0.             0.           5548.         91095.
TCC           377157.              0.             0.          24434.        401591.
TOTL         1135550.              0.             0.          57907.       1193457.
```

LSC-30-Unc, FF

```
MODEL BOILER   5                              4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                PM ROUTINE= FF           FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.050 EFF=  93.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   0.0   CTR=  0.0   EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     5
------------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
------------------------------------------------------------------------------------

EQUP         713439.             0.             0.           68816.         782255.
INST         630975.             0.             0.           66805.         697780.
TD          1344413.             0.             0.          135621.        1480034.
IND          437820.             0.             0.           53261.         491081.
TDI         1782233.             0.             0.          188882.        1971115.
CONT         356447.             0.             0.           37776.         394223.
TK          2138679.             0.             0.          226659.        2365337.
LAND           2000.             0.             0.               0.           2000.
WC           103737.             0.             0.            7642.         111379.




TOTL        2244416.             0.             0.          234300.        2478716.

DL            90863.             0.             0.            9998.         100860.
SPRV          44001.             0.             0.               0.          44001.
MANT          41173.             0.             0.           11202.          52374.
SP            65485.             0.             0.            3064.          68548.
ELEC              0.             0.             0.               0.              0.
UC            35718.             0.             0.            5408.          41126.
WTR               0.             0.             0.               0.              0.
SW            11092.             0.             0.             895.          11987.
SLDG              0.             0.             0.               0.              0.
LW                0.             0.             0.               0.              0.
SC                0.             0.             0.               0.              0.
LMS               0.             0.             0.               0.              0.
LIME              0.             0.             0.               0.              0.
NH3               0.             0.             0.               0.              0.
LYE               0.             0.             0.               0.              0.
FUEL         380009.             0.             0.               0.         380009.
TDOM         668339.             0.             0.           30566.         698905.
OH            90054.             0.             0.            9308.          99362.
TOTL         758393.             0.             0.           39874.         798267.

CR           281236.             0.             0.           29806.         311042.
WCC           10374.             0.             0.             764.          11138.
MISC          85547.             0.             0.            9066.          94613.
TCC          377157.             0.             0.           39636.         416793.
TOTL        1135550.             0.             0.           79510.        1215059.
```

LSC-30-DS(50), DS/PM

```
MODEL BOILER   6                                   4-06-82
BOILER ROUTINE UNDR     SO2 ROUTINE= DS               PM ROUTINE=                FLOW FLAG=    1

S STAR (METRIC) =       0.134
S DSTAR (METRIC) =       4.252
BOILER SPECIFICATIONS
   Q=       30.0 FLW= 11334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=    0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.100 EFF=   7.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315



COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.     6
-----------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
-----------------------------------------------------------------------------------

EQUP         713439.             0.             0.             0.        713439.
INST         630975.             0.             0.             0.        630975.
TD          1344413.             0.        317561.             0.       1661974.
IND          437820.             0.             0.             0.        437820.
TDI         1782233.             0.             0.             0.       1782233.
CONT         356447.             0.             0.             0.        356447.
TK          2138679.             0.        580391.             0.       2719069.
LAND           2000.             0.             0.             0.          2000.
WC           103737.             0.         41344.             0.        145082.
TOTL        2244416.             0.        621735.             0.       2866151.

DL            90863.             0.        105000.             0.        195863.
SPRV          44001.             0.         21000.             0.         65001.
MANT          41173.             0.         31556.             0.         72729.
SP            65485.             0.             0.             0.         65485.
ELEC              0.             0.          3294.             0.          3294.
UC            35718.             0.             0.             0.         35718.
WTR               0.             0.           160.             0.           160.
SW            11092.             0.          2597.             0.         13688.
SLDG              0.             0.             0.             0.             0.
LW                0.             0.             0.             0.             0.
SC                0.             0.             0.             0.             0.
LMS               0.             0.             0.             0.             0.
LIME              0.             0.          1770.             0.          1770.
NH3               0.             0.             0.             0.             0.
LYE               0.             0.             0.             0.             0.
FUEL         380009.             0.             0.             0.        380009.
TDOM         668339.             0.        165377.             0.        833716.
OM            90054.             0.         72465.             0.        162519.
TOTL         758393.             0.        237842.             0.        996235.

CR           281236.             0.         76321.             0.        357558.
WCC           10374.             0.          4134.             0.         14508.
MISC          85547.             0.         23216.             0.        108763.
TCC          377157.             0.        103671.             0.        480828.
TOTL        1135550.             0.        341513.             0.       1477063.
```

LSC-30-DA(50), DA/PM

```
MODEL BOILER   7                                  4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DAC          PM ROUTINE=              FLOW FLAG=    1

S STAR (METRIC)=      0.134
S DSTAR (METRIC)=      4.252
P DSTAR (METRIC)=    10.465
BOILER SPECIFICATIONS
   Q=      30.0 FLW= 11334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=    0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.100 EFF=  87.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     7
-------------------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
-------------------------------------------------------------------------------------------

EQUP          713439.              0.              0.              0.          713439.
INST          630975.              0.              0.              0.          630975.
TD           1344413.              0.         375726.              0.         1720139.
IND           437820.              0.              0.              0.          437820.
TDI          1782233.              0.              0.              0.         1782233.
CONT          356447.              0.              0.              0.          356447.
TK           2138679.              0.         649675.              0.         2788353.
LAND            2000.              0.              0.              0.            2000.
WC            103737.              0.          41417.              0.          145155.
TOTL         2244416.              0.         691092.              0.         2935508.

DL             90863.              0.         105000.              0.          195863.
SPRV           44001.              0.          21000.              0.           65001.
MANT           41173.              0.          30058.              0.           71231.
SP             65485.              0.              0.              0.           65485.
ELEC               0.              0.           3888.              0.            3888.
UC             35718.              0.              0.              0.           35718.
WTR                0.              0.            214.              0.             214.
SW             11092.              0.              0.              0.           11092.




SLDG               0.              0.           3472.              0.            3472.
LW                 0.              0.              0.              0.               0.
SC                 0.              0.            822.              0.             822.
LMS                0.              0.              0.              0.               0.
LIME               0.              0.           1215.              0.            1215.
NH3                0.              0.              0.              0.               0.
LYE                0.              0.              0.              0.               0.
FUEL          380009.              0.              0.              0.          380009.
TDOM          668339.              0.         165669.              0.          834008.
OM             90054.              0.          72075.              0.          162129.
TOTL          758393.              0.         237744.              0.          996138.

CR            281236.              0.          85432.              0.          366668.
WCC            10374.              0.           4142.              0.           14515.
MISC           85547.              0.          25987.              0.          111534.
TCC           377157.              0.         115561.              0.          492718.
TOTL         1135550.              0.         353305.              0.         1488854.
```

LSC-30-DA(50), FF

```
MODEL BOILER   8                             4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DA             PM ROUTINE= FF          FLOW FLAG=    1

S STAR (METRIC)=     0.134
S DSTAR (METRIC)=     4.252
BOILER SPECIFICATIONS
   Q=       30.0 FLW= 11334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.050 EFF=  93.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     8
-----------------------------------------------------------------------------------
ITEM        BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL       TOTAL
-----------------------------------------------------------------------------------

EQUP       713439.              0.              0.          68816.        782255.
INST       630975.              0.              0.          66805.        697780.




TD        1344413.              0.         271887.         135621.       1751921.
IND        437820.              0.              0.          53261.        491081.
TDI       1782233.              0.              0.         188882.       1971115.
CONT       356447.              0.              0.          37776.        394223.
TK        2138679.              0.         495993.         226659.       2861330.
LAND         2000.              0.              0.              0.          2000.
WC         103737.              0.          38609.           7642.        149988.
TOTL      2244416.              0.         534602.         234300.       3013318.

DL          90863.              0.         105000.           9998.        205860.
SPRV        44001.              0.          21000.              0.         65001.
MANT        41173.              0.          21751.          11202.         74125.
SP          65485.              0.              0.           3064.         68548.
ELEC            0.              0.           1871.              0.          1871.
UC          35718.              0.              0.           5408.         41126.
WTR             0.              0.            214.              0.           214.
SW          11092.              0.              0.            895.         11987.
SLDG            0.              0.           2564.              0.          2564.
LW              0.              0.              0.              0.             0.
SC              0.              0.            822.              0.           822.
LMS             0.              0.              0.              0.             0.
LIME            0.              0.           1215.              0.          1215.
NH3             0.              0.              0.              0.             0.
LYE             0.              0.              0.              0.             0.
FUEL       380009.              0.              0.              0.        380009.
TDOM       668339.              0.         154436.          30566.        853341.
OH          90054.              0.          69915.           9308.        169277.
TOTL       758393.              0.         224351.          39874.       1022618.

CR         281236.              0.          65223.          29806.        376265.
WCC         10374.              0.           3861.            764.         14999.
MISC        85547.              0.          19840.           9066.        114453.
TCC        377157.              0.          88924.          39636.        505717.
TOTL      1135550.              0.         313275.          79510.       1528333.
```

LSC-30-DA(90), DA/PM

```
MODEL BOILER   9                               4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DAC          PM ROUTINE=              FLOW FLAG=    1

S STAR (METRIC)=     0.242
S DSTAR (METRIC)=     7.654
P DSTAR (METRIC)=    10.465



BOILER SPECIFICATIONS
   Q=       30.0 FLW= 11334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.100 EFF=  87.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.119 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     9
--------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP         713439.            0.              0.             0.        713439.
INST         630975.            0.              0.             0.        630975.
TD          1344413.            0.         411402.             0.       1755814.
IND          437820.            0.              0.             0.        437820.
TDI         1782233.            0.              0.             0.       1782233.
CONT         356447.            0.              0.             0.        356447.
TK          2138679.            0.         702474.             0.       2841153.
LAND           2000.            0.              0.             0.          2000.
WC           103737.            0.          43006.             0.        146743.
TOTL        2244416.            0.         745480.             0.       2989895.

DL            90863.            0.         105000.             0.        195863.
SPRV          44001.            0.          21000.             0.         65001.
MANT          41173.            0.          32912.             0.         74085.
SP            65485.            0.              0.             0.         65485.
ELEC              0.            0.           3946.             0.          3946.
UC            35718.            0.              0.             0.         35718.
WTR               0.            0.            233.             0.           233.
SW            11092.            0.              0.             0.         11092.
SLDG              0.            0.           5755.             0.          5755.
LW                0.            0.              0.             0.             0.
SC                0.            0.            851.             0.           851.
LMS               0.            0.              0.             0.             0.
LIME              0.            0.           2324.             0.          2324.
NH3               0.            0.              0.             0.             0.
LYE               0.            0.              0.             0.             0.
FUEL         380009.            0.              0.             0.        380009.
TDOM         668339.            0.         172022.             0.        840361.
OH            90054.            0.          72817.             0.        162871.



TOTL         758393.            0.         244839.             0.       1003233.

CR           281236.            0.          92375.             0.        373612.
WCC           10374.            0.           4301.             0.         14674.
MISC          85547.            0.          28099.             0.        113646.
TCC          377157.            0.         124775.             0.        501932.
TOTL        1135550.            0.         369614.             0.       1505164.
```

LSC-30-DA(90), FF

```
MODEL BOILER  10                                 4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DA                 PM ROUTINE= FF            FLOW FLAG=    1

S STAR (METRIC)=      0.242
S DSTAR (METRIC)=      7.654
BOILER SPECIFICATIONS
   D=      30.0 FLW= 11334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.050 EFF=  93.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.119 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    10
-----------------------------------------------------------------------------------------
ITEM          BOILER            NOX CONTROL     SO2 CONTROL    PM CONTROL      TOTAL
-----------------------------------------------------------------------------------------

EQUP          713439.               0.              0.           68816.         782255.
INST          630975.               0.              0.           66805.         697780.
TD           1344413.               0.         309545.          135621.        1789579.
IND           437820.               0.              0.           53261.         491081.
TDI          1782233.               0.              0.          188882.        1971115.
CONT          356447.               0.              0.           37776.         394223.
TX           2138679.               0.         551727.          226659.        2917063.
LAND            2000.               0.              0.               0.           2000.
WC            103737.               0.          40229.            7642.         151608.
TOTL         2244416.               0.         591956.          234300.        3070672.

DL             90863.               0.         105000.            9998.         205860.




SPRV           44001.               0.          21000.               0.          65001.
MANT           41173.               0.          24764.           11202.          77138.
SP             65485.               0.              0.            3064.          68548.
ELEC               0.               0.           1899.               0.           1899.
UC             35718.               0.              0.            5408.          41126.
WTR                0.               0.            233.               0.            233.
SW             11092.               0.              0.             895.          11987.
SLDG               0.               0.           4847.               0.           4847.
LW                 0.               0.              0.               0.              0.
SC                 0.               0.            851.               0.            851.
LMS                0.               0.              0.               0.              0.
LIME               0.               0.           2324.               0.           2324.
NH3                0.               0.              0.               0.              0.
LYE                0.               0.              0.               0.              0.
FUEL          380009.               0.              0.               0.         380009.
TDOM          668339.               0.         160918.           30566.         859823.
OH             90054.               0.          70699.            9308.         170060.
TOTL          758393.               0.         231616.           39874.        1029883.

CR            281236.               0.          72552.           29806.         383594.
WCC            10374.               0.           4023.             764.          15161.
MISC           85547.               0.          22069.            9066.         116683.
TCC           377157.               0.          98644.           39636.         515437.
TOTL         1135550.               0.         330260.           79510.        1545319.
```

LSC-75-Unc, Unc

```
MODEL BOILER  11                                 4-06-82
BOILER ROUTINE UNDR     SO2 ROUTINE=                  PM ROUTINE=                FLOW FLAG=    1

BOILER SPECIFICATIONS
   B=       75.0 FLW= 28334. CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=     0.60 A=      5.40
PM EMISSIONS
   UNC=          CTR=          EFF=          CRF=
SO2 EMISSIONS
   UNC=          CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0250 WTR=    0.15 LIME= 35.00 ALS=    8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     11
--------------------------------------------------------------------------------
ITEM           BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL      TOTAL




--------------------------------------------------------------------------------

EQUP           1274262.            0.              0.              0.         1274262.
INST           1153531.            0.              0.              0.         1153531.
TD             2427793.            0.              0.              0.         2427793.
IND             791344.            0.              0.              0.          791344.
TDI            3219136.            0.              0.              0.         3219136.
CONT            643827.            0.              0.              0.          643827.
TK             3862963.            0.              0.              0.         3862963.
LAND              2000.            0.              0.              0.            2000.
WC              213998.            0.              0.              0.          213998.
TOTL           4078960.            0.              0.              0.         4078960.

DL              110903.            0.              0.              0.          110903.
SPRV            123519.            0.              0.              0.          123519.
MANT            117640.            0.              0.              0.          117640.
SP              105430.            0.              0.              0.          105430.
ELEC                 0.            0.              0.              0.               0.
UC               52224.            0.              0.              0.           52224.
WTR                  0.            0.              0.              0.               0.
SW               27729.            0.              0.              0.           27729.
SLDG                 0.            0.              0.              0.               0.
LW                   0.            0.              0.              0.               0.
SC                   0.            0.              0.              0.               0.
LMS                  0.            0.              0.              0.               0.
LIME                 0.            0.              0.              0.               0.
NH3                  0.            0.              0.              0.               0.
LYE                  0.            0.              0.              0.               0.
FUEL            950022.            0.              0.              0.          950022.
TDOM           1489466.            0.              0.              0.         1489466.
OH              152739.            0.              0.              0.          152739.
TOTL           1642204.            0.              0.              0.         1642204.

CR              507980.            0.              0.              0.          507980.
WCC              21400.            0.              0.              0.           21400.
MISC            154519.            0.              0.              0.          154519.
TCC             683898.            0.              0.              0.          683898.
TOTL           2326101.            0.              0.              0.         2326101.
```

LSC-75-Unc, SM

```
MODEL BOILER  12                                   4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                       PM ROUTINE= SM           FLOW FLAG=    1




BOILER SPECIFICATIONS
   Q=      75.0 FLW= 28334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.400 EFF=  50.00 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.00
COST SUMMARY TABLE - RUN NO.    12
----------------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL        TOTAL
----------------------------------------------------------------------------------------

EQUP         1274262.             0.              0.            72366.        1346627.
INST         1153531.             0.              0.               0.         1153531.
TD           2427793.             0.              0.            72366.        2500158.
IND           791344.             0.              0.            24122.         815466.
TDI          3219136.             0.              0.            96488.        3315623.
CONT          643827.             0.              0.            19298.         663125.
TK           3862963.             0.              0.           115785.        3978748.
LAND            2000.             0.              0.               0.            2000.
WC            213998.             0.              0.             5036.         219033.
TOTL         4078960.             0.              0.           120821.        4199780.

DL            110903.             0.              0.             6788.         117690.
SPRV          125519.             0.              0.             1018.         126538.
MANT          117640.             0.              0.             5789.         123428.
SP            105430.             0.              0.              482.         105913.
ELEC              0.              0.              0.             4862.           4862.
UC             52224.             0.              0.               0.           52224.
WTR               0.              0.              0.               0.              0.
SW             27729.             0.              0.             1203.          28932.
SLDG              0.              0.              0.               0.              0.
LW                0.              0.              0.               0.              0.
SC                0.              0.              0.               0.              0.
LMS               0.              0.              0.               0.              0.
LIME              0.              0.              0.               0.              0.
NH3               0.              0.              0.               0.              0.
LYE               0.              0.              0.               0.              0.
FUEL          950022.             0.              0.               0.          950022.
TDOM         1489466.             0.              0.            20142.        1509608.
OH            152739.             0.              0.             5696.         158435.



TOTL         1642204.             0.              0.            25838.        1668042.

CR            507980.             0.              0.            15226.         523205.
WCC            21400.             0.              0.              504.          21903.
MISC          154519.             0.              0.             4631.         159150.
TCC           683898.             0.              0.            20361.         704259.
TOTL         2326101.             0.              0.            46199.        2372300.
```

LSC-75-Unc, SSS

```
MODEL BOILER  13                                   4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                    PM ROUTINE= SSS          FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      75.0 FLW= 28334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=    0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.200 EFF=  75.20 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=         EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDS= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    13
---------------------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
---------------------------------------------------------------------------------------------

EQUP         1274262.              0.              0.          131667.        1405928.
INST         1153531.              0.              0.               0.        1153531.
TD           2427793.              0.              0.          131667.        2559459.
IND           791344.              0.              0.           43889.         835233.
TDI          3219136.              0.              0.          175556.        3394691.
CONT          643827.              0.              0.           35111.         678938.
TK           3862963.              0.              0.          210667.        4073629.
LAND            2000.              0.              0.               0.           2000.
WC            213998.              0.              0.            7722.         221720.
TOTL         4078960.              0.              0.          218389.        4297349.

DL            110903.              0.              0.            9502.         120405.
SPRV          125519.              0.              0.            1425.         126945.
MANT          117640.              0.              0.            9627.         127266.
SP            105430.              0.              0.             878.         106308.




ELEC              0.               0.              0.            7662.           7662.
UC             52224.              0.              0.               0.          52224.
WTR               0.               0.              0.               0.              0.
SW             27729.              0.              0.            1795.          29523.
SLDG              0.               0.              0.               0.              0.
LW                0.               0.              0.               0.              0.
SC                0.               0.              0.               0.              0.
LMS               0.               0.              0.               0.              0.
LIME              0.               0.              0.               0.              0.
NH3               0.               0.              0.               0.              0.
LYE               0.               0.              0.               0.              0.
FUEL          950022.              0.              0.               0.         950022.
TDOM         1489466.              0.              0.           30889.        1520355.
OH            152739.              0.              0.            8423.         161162.
TOTL         1642204.              0.              0.           39313.        1681516.

CR            507980.              0.              0.           27703.         535682.
WCC            21400.              0.              0.             772.          22172.
MISC          154519.              0.              0.            8427.         162945.
TCC           683898.              0.              0.           36902.         720799.
TOTL         2326101.              0.              0.           76214.        2402315.
```

LSC-75-Unc, VS

```
MODEL BOILER  14                                   4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                    PM ROUTINE= VS              FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      75.0 FLW= 28334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.100 EFF=  87.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    14
------------------------------------------------------------------------------------------
ITEM           BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
------------------------------------------------------------------------------------------

EQUP          1274262.              0.             0.           91915.        1366177.




INST          1153531.              0.             0.           60741.        1214271.
TD            2427793.              0.             0.          152656.        2580449.
IND            791344.              0.             0.           51873.         843217.
TDI           3219136.              0.             0.          204529.        3423664.
CONT           643827.              0.             0.           40906.         684733.
TK            3862963.              0.             0.          245434.        4108397.
LAND             2000.              0.             0.               0.           2000.
WC             213998.              0.             0.           11371.         225369.
TOTL          4078960.              0.             0.          256805.        4335765.

DL             110903.              0.             0.           13575.         124478.
SPRV           125519.              0.             0.               0.         125519.
MANT           117640.              0.             0.           12355.         129994.
SP             105430.              0.             0.               0.         105430.
ELEC               0.               0.             0.               0.              0.
UC              52224.              0.             0.           17463.          69686.
WTR                0.               0.             0.               0.              0.
SW              27729.              0.             0.            2090.          29819.
SLDG               0.               0.             0.               0.              0.
LW                 0.               0.             0.               0.              0.
SC                 0.               0.             0.               0.              0.
LMS                0.               0.             0.               0.              0.
LIME               0.               0.             0.               0.              0.
NH3                0.               0.             0.               0.              0.
LYE                0.               0.             0.               0.              0.
FUEL           950022.              0.             0.               0.         950022.
TDOM          1489466.              0.             0.           45483.        1534948.
OH             152739.              0.             0.           10814.         163553.
TOTL          1642204.              0.             0.           56297.        1698501.

CR             507980.              0.             0.           32275.         540254.
WCC             21400.              0.             0.            1137.          22537.
MISC           154519.              0.             0.            9817.         164336.
TCC            683898.              0.             0.           43229.         727127.
TOTL          2326101.              0.             0.           99526.        2425627.
```

LSC-75-Unc, FF

```
MODEL BOILER  15                                4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE=                     PM ROUTINE= FF            FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=       75.0 FLW= 28334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS




   FC=      2.41 H=     9600. S=      0.60 A=      5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.050 EFF=  93.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=          EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    15
-----------------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL       TOTAL
-----------------------------------------------------------------------------------------

EQUP        1274262.             0.             0.           166764.       1441026.
INST        1153531.             0.             0.           221228.       1374759.
TD          2427793.             0.             0.           387992.       2815785.
IND          791344.             0.             0.           113010.        904354.
TDI         3219136.             0.             0.           501002.       3720137.
CONT         643827.             0.             0.           100200.        744027.
TK          3862963.             0.             0.           601202.       4464165.
LAND           2000.             0.             0.                0.          2000.
WC           213998.             0.             0.            11995.        225993.
TOTL        4078960.             0.             0.           613197.       4692156.

DL           110903.             0.             0.            13575.        124478.
SPRV         125519.             0.             0.                0.        125519.
MANT         117640.             0.             0.            11577.        129217.
SP           105430.             0.             0.             7638.        113069.
ELEC              0.             0.             0.                0.             0.
UC            52224.             0.             0.            12951.         65174.
WTR               0.             0.             0.                0.             0.
SW            27729.             0.             0.             2238.         29967.
SLDG              0.             0.             0.                0.             0.
LW                0.             0.             0.                0.             0.
SC                0.             0.             0.                0.             0.
LMS               0.             0.             0.                0.             0.
LIME              0.             0.             0.                0.             0.
NH3               0.             0.             0.                0.             0.
LYE               0.             0.             0.                0.             0.
FUEL         950022.             0.             0.                0.        950022.
TDOM        1489466.             0.             0.            47979.       1537445.
OH           152739.             0.             0.            12598.        165337.
TOTL        1642204.             0.             0.            60577.       1702781.

CR           507980.             0.             0.            79058.        587038.




WCC           21400.             0.             0.             1199.         22599.
MISC         154519.             0.             0.            24048.        178567.
TCC          683898.             0.             0.           104306.        788203.
TOTL        2326101.             0.             0.           164883.       2490983.
```

LSC-75-DS(50), DS/PM

```
MODEL BOILER  16                                          4-06-82
BOILER ROUTINE UNDR     SO2 ROUTINE= DS              PM ROUTINE=                FLOW FLAG=    1

S STAR (METRIC) =        0.134
S DSTAR (METRIC) =       10.630
BOILER SPECIFICATIONS
   Q=       75.0 FLW= 28334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.100 EFF=  87.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    16
--------------------------------------------------------------------------------------------
ITEM          BOILER           NOX CONTROL    SO2 CONTROL    PM CONTROL       TOTAL
--------------------------------------------------------------------------------------------

EQUP        1274262.               0.              0.            0.         1274262.
INST        1153531.               0.              0.            0.         1153531.
TD          2427793.               0.         599363.            0.         3027156.
IND          791344.               0.              0.            0.          791344.
TDI         3219136.               0.              0.            0.         3219136.
CONT         643827.               0.              0.            0.          643827.
TK          3862963.               0.         997458.            0.         4860420.
LAND           2000.               0.              0.            0.            2000.
WC           213998.               0.          47136.            0.          261134.
TOTL        4078960.               0.        1044594.            0.         5123553.

DL           110903.               0.         105000.            0.          215903.
SPRV         125519.               0.          21000.            0.          146519.
MANT         117640.               0.          44246.            0.          161885.
SP           105430.               0.              0.            0.          105430.




ELEC              0.               0.           6982.            0.            6982.
UC            52224.               0.              0.            0.           52224.
WTR               0.               0.            401.            0.             401.
SW            27729.               0.           6492.            0.           34221.
SLDG              0.               0.              0.            0.               0.
LW                0.               0.              0.            0.               0.
SC                0.               0.              0.            0.               0.
LMS               0.               0.              0.            0.               0.
LIME              0.               0.           4425.            0.            4425.
NH3               0.               0.              0.            0.               0.
LYE               0.               0.              0.            0.               0.
FUEL         950022.               0.              0.            0.          950022.
TDOM        1489466.               0.         188546.            0.         1678011.
OH           152739.               0.          75764.            0.          228503.
TOTL        1642204.               0.         264310.            0.         1906513.

CR           507980.               0.         131166.            0.          639145.
WCC           21400.               0.           4714.            0.           26113.
MISC         154519.               0.          39898.            0.          194417.
TCC          683898.               0.         175778.            0.          859675.
TOTL        2326101.               0.         440087.            0.         2766188.
```

LSC-75-DA(50), DA/PM

```
MODEL BOILER  17                                  4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DAC               PM ROUTINE=                   FLOW FLAG=    1

S STAR (METRIC)=      0.134
S DSTAR (METRIC)=     10.630
P DSTAR (METRIC)=     26.163
BOILER SPECIFICATIONS
   Q=       75.0 FLW= 28334. CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=     0.60 A=      5.40
PM EMISSIONS
   UNC=    0.807 CTR=  0.100 EFF=  87.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=    1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    17
--------------------------------------------------------------------------------


ITEM          BOILER        NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
--------------------------------------------------------------------------------

EQUP         1274262.            0.             0.            0.        1274262.
INST         1153531.            0.             0.            0.        1153531.
TD           2427793.            0.        549173.            0.        2976965.
IND           791344.            0.             0.            0.         791344.
TDI          3219136.            0.             0.            0.        3219136.
CONT          643827.            0.             0.            0.         643827.
TK           3862963.            0.        906376.            0.        4769338.
LAND            2000.            0.             0.            0.           2000.
WC            213998.            0.         48805.            0.         262803.
TOTL         4078960.            0.        955181.            0.        5034141.

DL            110903.            0.        105000.            0.         215903.
SPRV          125519.            0.         21000.            0.         146519.
MANT          117640.            0.         43934.            0.         161573.
SP            105430.            0.             0.            0.         105430.
ELEC              0.             0.          9721.            0.           9721.
UC             52224.            0.             0.            0.          52224.
WTR               0.             0.           463.            0.            463.
SW             27729.            0.             0.            0.          27729.
SLDG              0.             0.          9116.            0.           9116.
LW                0.             0.             0.            0.              0.
SC                0.             0.          2693.            0.           2693.
LMS               0.             0.             0.            0.              0.
LIME              0.             0.          3295.            0.           3295.
NH3               0.             0.             0.            0.              0.
LYE               0.             0.             0.            0.              0.
FUEL          950022.            0.             0.            0.         950022.
TDOM         1489466.            0.        195221.            0.        1684687.
OH            152739.            0.         75683.            0.         228422.
TOTL         1642204.            0.        270904.            0.        1913108.

CR            507980.            0.        119188.            0.         627168.
WCC            21400.            0.          4881.            0.          26280.
MISC          154519.            0.         36255.            0.         190774.
TCC           683898.            0.        160324.            0.         844222.
TOTL         2326101.            0.        431228.            0.        2757329.
```

LSC-75-DA(50), FF

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MODEL BOILER  18                                4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DA              PM ROUTINE= FF           FLOW FLAG=    1




S STAR (METRIC)=      0.134
S DSTAR (METRIC)=    10.630
BOILER SPECIFICATIONS
   Q=       75.0 FLW= 28334. CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=    9600. S=     0.60 A=      5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.050 EFF=  93.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    18
--------------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
--------------------------------------------------------------------------------------

EQUP        1274262.              0.             0.          166764.      1441026.
INST        1153531.              0.             0.          221228.      1374759.
TD          2427793.              0.        428814.          387992.      3244598.
IND          791344.              0.             0.          113010.       904354.
TDI         3219136.              0.             0.          501002.      3720137.
CONT         643827.              0.             0.          100200.       744027.
TK          3862963.              0.        728244.          601202.      5192408.
LAND           2000.              0.             0.              0.          2000.
WC           213998.              0.         44569.           11995.       270562.
TOTL        4078960.              0.        772813.          613197.      5464969.

DL           110903.              0.        105000.           13575.       229478.
SPRV         125519.              0.         21000.              0.        146519.
MANT         117640.              0.         34305.           11577.       163522.
SP           105430.              0.             0.            7638.       113069.
ELEC              0.              0.          4677.              0.          4677.
UC            52224.              0.             0.           12951.        65174.
WTR               0.              0.           463.              0.           463.
SW            27729.              0.             0.            2238.        29967.
SLDG              0.              0.          6844.              0.          6844.
LW                0.              0.             0.              0.             0.
SC                0.              0.          2693.              0.          2693.
LMS               0.              0.             0.              0.             0.
LIME              0.              0.          3295.              0.          3295.
NH3               0.              0.             0.              0.             0.




LYE               0.              0.             0.              0.             0.
FUEL         950022.              0.             0.              0.        950022.
TDOM        1489466.              0.        178278.           47979.      1715722.
OH           152739.              0.         73179.           12598.       238516.
TOTL        1642204.              0.        251457.           60577.      1954238.

CR           507980.              0.         95764.           79058.       682802.
WCC           21400.              0.          4457.            1199.        27056.
MISC         154519.              0.         29130.           24048.       207696.
TCC          683898.              0.        129351.          104306.       917554.
TOTL        2326101.              0.        380808.          164883.      2871790.
```

LSC-75-DA(90), DA/PM

```
MODEL BOILER  19                              4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DAC          PM ROUTINE=                FLOW FLAG=    1

S STAR (METRIC)=      0.242
S DSTAR (METRIC)=     19.134
P DSTAR (METRIC)=     26.163
BOILER SPECIFICATIONS
   Q=       75.0 FLW= 28334. CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=     0.60 A=      5.40
PM EMISSIONS
   UNC=    0.807 CTR=  0.100 EFF=  87.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=    1.190 CTR=  0.119 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    19
--------------------------------------------------------------------------------
ITEM          BOILER     NOX CONTROL    SO2 CONTROL     PM CONTROL          TOTAL
--------------------------------------------------------------------------------

EQUP         1274262.             0.             0.             0.       1274262.
INST         1153531.             0.             0.             0.       1153531.
TD           2427793.             0.        595733.             0.       3023525.
IND           791344.             0.             0.             0.        791344.
TDI          3219136.             0.             0.             0.       3219136.
CONT          643827.             0.             0.             0.        643827.
TK           3862963.             0.        975284.             0.       4838247.




LAND            2000.             0.             0.             0.          2000.
WC            213998.             0.         51927.             0.        265925.
TOTL         4078960.             0.       1027212.             0.       5106171.

DL            110903.             0.        105000.             0.        215903.
SPRV          125519.             0.         21000.             0.        146519.
MANT          117640.             0.         47659.             0.        165298.
SP            105430.             0.             0.             0.        105430.
ELEC              0.             0.          9865.             0.          9865.
UC             52224.             0.             0.             0.         52224.
WTR               0.             0.           506.             0.           506.
SW             27729.             0.             0.             0.         27729.
SLDG              0.             0.         14824.             0.         14824.
LW                0.             0.             0.             0.             0.
SC                0.             0.          2788.             0.          2788.
LMS               0.             0.             0.             0.             0.
LIME              0.             0.          6069.             0.          6069.
NH3               0.             0.             0.             0.             0.
LYE               0.             0.             0.             0.             0.
FUEL          950022.             0.             0.             0.        950022.
TDOM         1489466.             0.        207710.             0.       1697175.
OH            152739.             0.         76651.             0.        229390.
TOTL         1642204.             0.        284361.             0.       1926564.

CR            507980.             0.        128250.             0.        636230.
WCC            21400.             0.          5193.             0.         26593.
MISC          154519.             0.         39011.             0.        193530.
TCC           683898.             0.        172454.             0.        856352.
TOTL         2326101.             0.        456815.             0.       2782915.
```

LSC-75-DA(90), FF

```
MODEL BOILER  20                                   4-06-82
BOILER ROUTINE UNDR    SO2 ROUTINE= DA              PM ROUTINE= FF               FLOW FLAG=    1

S STAR (METRIC)=      0.242
S DSTAR (METRIC)=    19.134
BOILER SPECIFICATIONS
   Q=       75.0 FLW= 28334. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   0.807 CTR=  0.050 EFF=  93.80 CRF= 0.1315



SO2 EMISSIONS
   UNC=   1.190 CTR=  0.119 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    20
----------------------------------------------------------------------------------------------
ITEM          BOILER            NOX CONTROL    SO2 CONTROL     PM CONTROL      TOTAL
----------------------------------------------------------------------------------------------

EQUP         1274262.               0.              0.          166764.        1441026.
INST         1153531.               0.              0.          221228.        1374759.
TD           2427793.               0.         482647.          387992.        3298432.
IND           791344.               0.              0.          113010.         904354.
TDI          3219136.               0.              0.          501002.        3720137.
CONT          643827.               0.              0.          100200.         744027.
TK           3862963.               0.         807917.          601202.        5272082.
LAND            2000.               0.              0.               0.           2000.
WC            213998.               0.          47818.           11995.         273811.
TOTL         4078960.               0.         855736.          613197.        5547891.

DL            110903.               0.         105000.           13575.         229478.
SPRV          125519.               0.          21000.               0.         146519.
MANT          117640.               0.          38612.           11577.         167828.
SP            105430.               0.              0.            7638.         113069.
ELEC              0.                0.           4747.               0.           4747.
UC             52224.               0.              0.           12951.          65174.
WTR               0.                0.            506.               0.            506.
SW             27729.               0.              0.            2238.          29967.
SLDG              0.                0.          12552.               0.          12552.
LW                0.                0.              0.               0.              0.
SC                0.                0.           2788.               0.           2788.
LMS               0.                0.              0.               0.              0.
LIME              0.                0.           6069.               0.           6069.
NH3               0.                0.              0.               0.              0.
LYE               0.                0.              0.               0.              0.
FUEL          950022.               0.              0.               0.         950022.
TDOM         1489466.               0.         191273.           47979.        1728718.
OH            152739.               0.          74299.           12598.         239636.
TOTL         1642204.               0.         265572.           60577.        1968353.

CR            507980.               0.         106241.           79058.         693279.
WCC            21400.               0.           4782.            1199.          27381.
MISC          154519.               0.          32317.           24048.         210883.
TCC           683898.               0.         143340.          104306.         931543.




TOTL         2326101.               0.         408912.          164883.        2899894.
```

LSC-150-Unc, Unc

```
MODEL BOILER  21
BOILER ROUTINE SPRD    SO2 ROUTINE=             4-06-82
                                                     PM ROUTINE=                    FLOW FLAG=    1
BOILER SPECIFICATIONS
   G=     150.0 FLW= 56669. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=    0.60 A=     5.40
PM EMISSIONS
   UNC=         CTR=          EFF=         CRF=
SO2 EMISSIONS
   UNC=         CTR=          EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    21
-----------------------------------------------------------------------------------------
ITEM            BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL       TOTAL
-----------------------------------------------------------------------------------------

EQUP           2732516.              0.             0.             0.        2732516.
INST           2327704.              0.             0.             0.        2327704.
TD             5060220.              0.             0.             0.        5060220.
IND            1629384.              0.             0.             0.        1629384.
TDI            6689604.              0.             0.             0.        6689604.
CONT           1337920.              0.             0.             0.        1337920.
TK             8027524.              0.             0.             0.        8027524.
LAND              2000.              0.             0.             0.           2000.
WC              304323.              0.             0.             0.         304323.
TOTL           8333846.              0.             0.             0.        8333846.

DL              186128.              0.             0.             0.         186128.
SPRV             78752.              0.             0.             0.          78752.
MANT             85796.              0.             0.             0.          85796.
SP              153400.              0.             0.             0.         153400.
ELEC                 0.              0.             0.             0.              0.
UC               69844.              0.             0.             0.          69844.
WTR                  0.              0.             0.             0.              0.
SW               10276.              0.             0.             0.          10276.
SLDG                 0.              0.             0.             0.              0.
LW                   0.              0.             0.             0.              0.



SC                   0.              0.             0.             0.              0.
LMS                  0.              0.             0.             0.              0.
LIME                 0.              0.             0.             0.              0.
NH3                  0.              0.             0.             0.              0.
LYE                  0.              0.             0.             0.              0.
FUEL           1900043.              0.             0.             0.        1900043.
TDOM           2484239.              0.             0.             0.        2484239.
OH              186898.              0.             0.             0.         186898.
TOTL           2671136.              0.             0.             0.        2671136.

CR             1055619.              0.             0.             0.        1055619.
WCC              30432.              0.             0.             0.          30432.
MISC            321101.              0.             0.             0.         321101.
TCC            1407151.              0.             0.             0.        1407151.
TOTL           4078287.              0.             0.             0.        4078287.
```

LSC-150-Unc, SM

```
MODEL BOILER  22                                  4-06-82
BOILER ROUTINE SPRD    SO2 ROUTINE=                   PM ROUTINE= SM           FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=      150.0 FLW= 56669. CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=    3.130 CTR=  0.600 EFF=  80.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=          CTR=          EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    22
------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL    TOTAL
------------------------------------------------------------------------------

EQUP         2732516.             0.             0.          121856.     2854372.
INST         2327704.             0.             0.              0.      2327704.
TD           5060220.             0.             0.          121856.     5182076.
IND          1629384.             0.             0.           40619.     1670002.
TDI          6689604.             0.             0.          162475.     6852079.
CONT         1337920.             0.             0.           32495.     1370415.
TK           8027524.             0.             0.          194970.     8222494.




LAND            2000.             0.             0.              0.         2000.
WC            304323.             0.             0.           10798.      315120.
TOTL         8333846.             0.             0.          205768.     8539613.

DL            186128.             0.             0.            9769.      195897.
SPRV           78752.             0.             0.            1465.       80217.
MANT           85796.             0.             0.            6459.       92255.
SP            153400.             0.             0.             812.      154212.
ELEC              0.             0.             0.            9724.        9724.
UC             69844.             0.             0.              0.        69844.
WTR               0.             0.             0.              0.            0.
SW             10276.             0.             0.           14960.       25236.
SLDG              0.             0.             0.              0.            0.
LW                0.             0.             0.              0.            0.
SC                0.             0.             0.              0.            0.
LMS               0.             0.             0.              0.            0.
LIME              0.             0.             0.              0.            0.
NH3               0.             0.             0.              0.            0.
LYE               0.             0.             0.              0.            0.
FUEL         1900043.             0.             0.              0.      1900043.
TDOM         2484239.             0.             0.           43190.     2527429.
OH            186898.             0.             0.            7742.      194640.
TOTL         2671136.             0.             0.           50932.     2722068.

CR           1055619.             0.             0.           25639.     1081257.
WCC            30432.             0.             0.            1080.       31512.
MISC          321101.             0.             0.            7799.      328900.
TCC          1407151.             0.             0.           34517.     1441668.
TOTL         4078287.             0.             0.           85449.     4163736.
```

LSC-150-Unc, SSS

```
MODEL BOILER  23                                   4-06-82
BOILER ROUTINE SPRD     SO2 ROUTINE=                   PM ROUTINE= SSS          FLOW FLAG=     1

BOILER SPECIFICATIONS
   Q=      150.0 FLW= 56669. CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=     0.60 A=      5.40
PM EMISSIONS
   UNC=    3.130 CTR=  0.200 EFF=  93.60 CRF= 0.1315
SO2 EMISSInNS
   UNC=          CTR=           EFF=          CRF=
COST RATES



   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    23
--------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP         2732516.            0.             0.          227173.      2959689.
INST         2327704.            0.             0.              0.       2327704.
TD           5060220.            0.             0.          227173.      5287393.
IND          1629384.            0.             0.           75724.      1705108.
TDI          6689604.            0.             0.          302897.      6992501.
CONT         1337920.            0.             0.           60579.      1398499.
TK           8027524.            0.             0.          363477.      8391000.
LAND            2000.            0.             0.              0.          2000.
WC            304323.            0.             0.           15448.       319770.
TOTL         8333846.            0.             0.          378925.      8712770.

DL            186128.            0.             0.           13676.       199804.
SPRV           78752.            0.             0.            2051.        80803.
MANT           85796.            0.             0.           12079.        97875.
SP            153400.            0.             0.            1514.       154914.
ELEC              0.             0.             0.           15145.        15145.
UC             69844.            0.             0.              0.         69844.
WTR               0.             0.             0.              0.             0.
SW             10276.            0.             0.           17325.        27601.
SLDG              0.             0.             0.              0.             0.
LW                0.             0.             0.              0.             0.
SC                0.             0.             0.              0.             0.
LMS               0.             0.             0.              0.             0.
LIME              0.             0.             0.              0.             0.
NH3               0.             0.             0.              0.             0.
LYE               0.             0.             0.              0.             0.
FUEL         1900043.            0.             0.              0.       1900043.
TDOM         2484239.            0.             0.           61792.      2546030.
OH            186898.            0.             0.           11726.       198624.
TOTL         2671136.            0.             0.           73518.      2744654.

CR           1055619.            0.             0.           47797.      1103416.
WCC            30432.            0.             0.            1545.        31977.
MISC          321101.            0.             0.           14539.       335640.
TCC          1407151.            0.             0.           63881.      1471032.
TOTL         4078287.            0.             0.          137399.      4215686.
```

LSC-150-Unc, VS

```
MODEL BOILER  24                                  4-06-82
BOILER ROUTINE SPRD    SO2 ROUTINE=                  PM ROUTINE= VS           FLOW FLAG=    1

BOILER SPECIFICATIONS
   Q=     150.0 FLW= 56669. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   3.130 CTR=  0.100 EFF=  96.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=          EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    24
------------------------------------------------------------------------------------
ITEM         BOILER           NOX CONTROL     SO2 CONTROL     PM CONTROL      TOTAL
------------------------------------------------------------------------------------

EQUP        2732516.              0.              0.           156914.      2889430.
INST        2327704.              0.              0.           107578.      2435281.
TD          5060220.              0.              0.           264492.      5324712.
IND         1629384.              0.              0.            88283.      1717666.
TDI         6689604.              0.              0.           352775.      7042378.
CONT        1337920.              0.              0.            70555.      1408474.
TK          8027524.              0.              0.           423330.      8450853.
LAND           2000.              0.              0.                0.         2000.
WC           304323.              0.              0.            22774.       327096.
TOTL        8333846.              0.              0.           446103.      8779949.

DL           186128.              0.              0.            19538.       205665.
SPRV          78752.              0.              0.                0.        78752.
MANT          85796.              0.              0.            20185.       105981.
SP           153400.              0.              0.                0.       153400.
ELEC              0.              0.              0.                0.            0.
UC            69844.              0.              0.            33456.       103301.
WTR               0.              0.              0.                0.            0.
SW            10276.              0.              0.            17916.        28193.
SLDG              0.              0.              0.                0.            0.
LW                0.              0.              0.                0.            0.
SC                0.              0.              0.                0.            0.
LMS               0.              0.              0.                0.            0.
LIME              0.              0.              0.                0.            0.




NH3               0.              0.              0.                0.            0.
LYE               0.              0.              0.                0.            0.
FUEL        1900043.              0.              0.                0.      1900043.
TDOM        2484239.              0.              0.            91095.      2575333.
OH           186898.              0.              0.            16189.       203087.
TOTL        2671136.              0.              0.           107284.      2778420.

CR          1055619.              0.              0.            55668.      1111286.
WCC           30432.              0.              0.             2277.        32710.
MISC         321101.              0.              0.            16933.       338034.
TCC         1407151.              0.              0.            74878.      1482029.
TOTL        4078287.              0.              0.           182162.      4260449.
```

LSC-150-Unc, FF

```
MODEL BOILER  25                                4-06-82
BOILER ROUTINE SPRD    SO2 ROUTINE=                PM ROUTINE= FF            FLOW FLAG=    1
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 56669. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   3.130 CTR=  0.050 EFF=  98.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=          EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    25
------------------------------------------------------------------------------------------
ITEM           BOILER           NOX CONTROL    SO2 CONTROL     PM CONTROL       TOTAL
------------------------------------------------------------------------------------------

EQUP          2732516.              0.             0.          325760.        3058275.
INST          2327704.              0.             0.          338045.        2665749.
TD            5060220.              0.             0.          663805.        5724024.
IND           1629384.              0.             0.          199647.        1829030.
TDI           6689604.              0.             0.          863452.        7553055.
CONT          1337920.              0.             0.          172690.        1510610.
TK            8027524.              0.             0.         1036142.        9063665.
LAND             2000.              0.             0.               0.           2000.
WC             304323.              0.             0.           22746.         327069.
TOTL          8333846.              0.             0.         1058887.        9392733.



DL             186128.              0.             0.           19538.         205665.
SPRV            78752.              0.             0.               0.          78752.
MANT            85796.              0.             0.           12919.          98715.
SP             153400.              0.             0.           15245.         168645.
ELEC                0.              0.             0.               0.              0.
UC              69844.              0.             0.           25071.          94915.
WTR                 0.              0.             0.               0.              0.
SW              10276.              0.             0.           18212.          28488.
SLDG                0.              0.             0.               0.              0.
LW                  0.              0.             0.               0.              0.
SC                  0.              0.             0.               0.              0.
LMS                 0.              0.             0.               0.              0.
LIME                0.              0.             0.               0.              0.
NH3                 0.              0.             0.               0.              0.
LYE                 0.              0.             0.               0.              0.
FUEL          1900043.              0.             0.               0.        1900043.
TDOM          2484239.              0.             0.           90984.        2575223.
OH             186898.              0.             0.           18264.         205162.
TOTL          2671136.              0.             0.          109248.        2780383.

CR            1055619.              0.             0.          136253.        1191871.
WCC             30432.              0.             0.            2275.          32707.
MISC           321101.              0.             0.           41446.         362547.
TCC           1407151.              0.             0.          179973.        1587123.
TOTL          4078287.              0.             0.          289221.        4367507.
```

LSC-150-DS(50), DS/PM

```
MODEL BOILER  26                              4-06-82
BOILER ROUTINE SPRD    SO2 ROUTINE= DS            PM ROUTINE=                FLOW FLAG=    1

S STAR (METRIC) =      0.134
S DSTAR (METRIC) =     21.260
BOILER SPECIFICATIONS
   Q=      150.0 FLW= 56669. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   3.130 CTR=  0.100 EFF=  96.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES



   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    26
-------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
-------------------------------------------------------------------------------

EQUP        2732516.             0.              0.            0.        2732516.
INST        2327704.             0.              0.            0.        2327704.
TD          5060220.             0.         991508.            0.        6051727.
IND         1629384.             0.              0.            0.        1629384.
TDI         6689604.             0.              0.            0.        6689604.
CONT        1337920.             0.              0.            0.        1337920.
TK          8027524.             0.        1577831.            0.        9605355.
LAND           2000.             0.              0.            0.           2000.
WC           304323.             0.          59216.            0.         363538.
TOTL        8333846.             0.        1637046.            0.        997089[illegible].

DL           186128.             0.         105000.            0.         291128.
SPRV          78752.             0.          21000.            0.          99752.
MANT          85796.             0.          62166.            0.         147962.
SP           153400.             0.              0.            0.         153400.
ELEC             0.              0.          12326.            0.          12326.
UC            69844.             0.              0.            0.          69844.
WTR              0.              0.            802.            0.            802.
SW            10276.             0.          26720.            0.          36996.
SLDG             0.              0.              0.            0.              0.
LW               0.              0.              0.            0.              0.
SC               0.              0.              0.            0.              0.
LMS              0.              0.              0.            0.              0.
LIME             0.              0.           8849.            0.           8849.
NH3              0.              0.              0.            0.              0.
LYE              0.              0.              0.            0.              0.
FUEL        1900043.             0.              0.            0.        1900043.
TDOM        2484239.             0.         236863.            0.        2721102.
OH           186898.             0.          80423.            0.         267321.
TOTL        2671136.             0.         317287.            0.        2988422.

CR          1055619.             0.         207485.            0.        1263103.
WCC           30432.             0.           5922.            0.          36354.
MISC         321101.             0.          63113.            0.         384214.
TCC         1407151.             0.         276520.            0.        1683670.
TOTL        4078287.             0.         593806.            0.        4672093.
```

LSC-150-DA(50), DA/PM

```
MODEL BOILER  27                                  4-06-82
BOILER ROUTINE SPRD     SO2 ROUTINE= DAC             PM ROUTINE=                 FLOW FLAG=    1

S STAR (METRIC)=      0.134
S DSTAR (METRIC)=    21.260
P DSTAR (METRIC)=   242.150
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 56669. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   3.130 CTR=  0.100 EFF=  96.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    27
-------------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL       TOTAL
-------------------------------------------------------------------------------------

EQUP        2732516.              0.              0.            0.         2732516.
INST        2327704.              0.              0.            0.         2327704.
TD          5060220.              0.         810758.            0.         5870977.
IND         1629384.              0.              0.            0.         1629384.
TDI         6689604.              0.              0.            0.         6689604.
CONT        1337920.              0.              0.            0.         1337920.
TK          8027524.              0.        1293521.            0.         9321045.
LAND           2000.              0.              0.            0.            2000.
WC           304323.              0.          64689.            0.          369012.
TOTL        8333846.              0.        1358210.            0.         9692056.

DL           186128.              0.         105000.            0.          291128.
SPRV          78752.              0.          21000.            0.           99752.
MANT          85796.              0.          64861.            0.          150657.
SP           153400.              0.              0.            0.          153400.
ELEC              0.              0.          19442.            0.           19442.
UC            69844.              0.              0.            0.           69844.
WTR               0.              0.            879.            0.             879.
SW            10276.              0.              0.            0.           10276.
SLDG              0.              0.          35004.            0.           35004.



LW                0.              0.              0.            0.               0.
SC                0.              0.           5810.            0.            5810.
LMS               0.              0.              0.            0.               0.
LIME              0.              0.           6762.            0.            6762.
NH3               0.              0.              0.            0.               0.
LYE               0.              0.              0.            0.               0.
FUEL        1900043.              0.              0.            0.         1900043.
TDOM        2484239.              0.         258757.            0.         2742996.
OH           186898.              0.          81124.            0.          268022.
TOTL        2671136.              0.         339881.            0.         3011017.

CR          1055619.              0.         170098.            0.         1225717.
WCC           30432.              0.           6469.            0.           36901.
MISC         321101.              0.          51741.            0.          372842.
TCC         1407151.              0.         228308.            0.         1635458.
TOTL        4078287.              0.         568189.            0.         4646475.
```

LSC-150-DA(50), FF

```
MODEL BOILER  28                                    4-06-82
BOILER ROUTINE SPRD    SO2 ROUTINE= DA          PM ROUTINE= FF            FLOW FLAG=    1

S STAR (METRIC)=     0.134
S DSTAR (METRIC)=    21.260
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 56669. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   3.130 CTR=  0.050 EFF=  98.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.00

COST SUMMARY TABLE - RUN NO.    28
-----------------------------------------------------------------------------------------
ITEM           BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
-----------------------------------------------------------------------------------------

EQUP          2732516.               0.              0.          325760.       3058275.
INST          2327704.               0.              0.          338045.       2665749.
TD            5060220.               0.         609376.          663805.       6333399.




IND           1629384.               0.              0.          199647.       1829030.
TDI           6689604.               0.              0.          863452.       7553055.
CONT          1337920.               0.              0.          172690.       1510610.
TK            8027524.               0.         995476.         1036142.      10059140.
LAND             2000.               0.              0.               0.          2000.
WC             304323.               0.          52884.           22746.        379952.
TOTL          8333846.               0.        1048359.         1058887.      10441092.

DL             186128.               0.         105000.           19538.        310665.
SPRV            78752.               0.          21000.               0.         99752.
MANT            85796.               0.          48750.           12919.        147465.
SP             153400.               0.              0.           15245.        168645.
ELEC                0.               0.           9355.               0.          9355.
UC              69844.               0.              0.           25071.         94915.
WTR                 0.               0.            879.               0.           879.
SW              10276.               0.              0.           18212.         28488.
SLDG                0.               0.          13979.               0.         13979.
LW                  0.               0.              0.               0.             0.
SC                  0.               0.           5810.               0.          5810.
LMS                 0.               0.              0.               0.             0.
LIME                0.               0.           6762.               0.          6762.
NH3                 0.               0.              0.               0.             0.
LYE                 0.               0.              0.               0.             0.
FUEL          1900043.               0.              0.               0.       1900043.
TDOM          2484239.               0.         211535.           90984.       2786758.
OH             186898.               0.          76935.           18264.        282096.
TOTL          2671136.               0.         288470.          109248.       3068853.

CR            1055619.               0.         130905.          136253.       1322776.
WCC             30432.               0.           5288.            2275.         37995.
MISC           321101.               0.          39819.           41446.        402366.
TCC           1407151.               0.         176012.          179973.       1763135.
TOTL          4078287.               0.         464482.          289221.       4831989.
```

LSC-150-DA(90), DA/PM

```
MODEL BOILER  29                           4-06-82
BOILER ROUTINE SPRD    SO2 ROUTINE= DAC         PM ROUTINE=              FLOW FLAG=    1

S STAR (METRIC)=     0.242
S DSTAR (METRIC)=   38.268
P DSTAR (METRIC)=  242.150
BOILER SPECIFICATIONS




   Q=     150.0 FLW= 56669. CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=    2.41 H=    9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   3.130 CTR=  0.100 EFF=  96.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.119 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    29
--------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP        2732516.            0.             0.             0.       2732516.
INST        2327704.            0.             0.             0.       2327704.
TD          5060220.            0.        857321.             0.       5917541.
IND         1629384.            0.             0.             0.       1629384.
TDI         6689604.            0.             0.             0.       6689604.
CONT        1337920.            0.             0.             0.       1337920.
TK          8027524.            0.       1362434.             0.       9389958.
LAND           2000.            0.             0.             0.          2000.
WC           304323.            0.         70005.             0.        374328.
TOTL        8333846.            0.       1432439.             0.       9766285.

DL           186128.            0.        105000.             0.        291128.
SPRV          78752.            0.         21000.             0.         99752.
MANT          85796.            0.         68586.             0.        154382.
SP           153400.            0.             0.             0.        153400.
ELEC              0.            0.         19730.             0.         19730.
UC            69844.            0.             0.             0.         69844.
WTR               0.            0.           960.             0.           960.
SW            10276.            0.             0.             0.         10276.
SLDG              0.            0.         46419.             0.         46419.
LW                0.            0.             0.             0.             0.
SC                0.            0.          6016.             0.          6016.
LMS               0.            0.             0.             0.             0.
LIME              0.            0.         12310.             0.         12310.
NH3               0.            0.             0.             0.             0.
LYE               0.            0.             0.             0.             0.
FUEL        1900043.            0.             0.             0.       1900043.
TDOM        2484239.            0.        280020.             0.       2764259.
OH           186898.            0.         82092.             0.        268990.
TOTL        2671136.            0.        362113.             0.       3033248.




CR          1055619.            0.        179160.             0.       1234779.
WCC           30432.            0.          7001.             0.         37433.
MISC         321101.            0.         54497.             0.        375598.
TCC         1407151.            0.        240658.             0.       1647808.
TOTL        4078287.            0.        602770.             0.       4681057.
```

LSC-150-DA(90), FF

```
MODEL BOILER  30                                   4-06-82
BOILER ROUTINE SPRD    SO2 ROUTINE= DA                 PM ROUTINE= FF           FLOW FLAG=    1

S STAR (METRIC)=      0.242
S DSTAR (METRIC)=     38.268
BOILER SPECIFICATIONS
   Q=      150.0 FLW= 56669. CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=      0.60 A=      5.40
PM EMISSIONS
   UNC=   3.130 CTR=  0.050 EFF=  98.40 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.119 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    30
-------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
-------------------------------------------------------------------------------

EQUP         2732516.             0.             0.        325760.      3058275.
INST         2327704.             0.             0.        338045.      2665749.
TD           5060220.             0.        679919.        663805.      6403942.
IND          1629384.             0.             0.        199647.      1829030.
TDI          6689604.             0.             0.        863452.      7553055.
CONT         1337920.             0.             0.        172690.      1510610.
TK           8027524.             0.       1099879.       1036142.     10163544.
LAND            2000.             0.             0.             0.         2000.
WC            304323.             0.         58642.         22746.       385710.
TOTL         8333846.             0.       1158520.       1058887.     10551253.

DL            186128.             0.        105000.         19538.       310665.
SPRV           78752.             0.         21000.             0.        99752.



MANT           85796.             0.         54393.         12919.       153108.
SP            153400.             0.             0.         15245.       168645.
ELEC               0.             0.          9494.             0.         9494.
UC             69844.             0.             0.         25071.        94915.
WTR                0.             0.           960.             0.          960.
SW             10276.             0.             0.         18212.        28488.
SLDG               0.             0.         25394.             0.        25394.
LW                 0.             0.             0.             0.            0.
SC                 0.             0.          6016.             0.         6016.
LMS                0.             0.             0.             0.            0.
LIME               0.             0.         12310.             0.        12310.
NH3                0.             0.             0.             0.            0.
LYE                0.             0.             0.             0.            0.
FUEL         1900043.             0.             0.             0.      1900043.
TDOM         2484239.             0.        234567.         90984.      2809789.
OH            186898.             0.         78402.         18264.       283564.
TOTL         2671136.             0.        312969.        109248.      3093352.

CR           1055619.             0.        144634.        136253.      1336505.
WCC            30432.             0.          5864.          2275.        38571.
MISC          321101.             0.         43995.         41446.       406542.
TCC          1407151.             0.        194493.        179973.      1781616.
TOTL         4078287.             0.        507462.        289221.      4874969.
```

LSC-400-Unc, Unc

```
MODEL BOILER  31                                   4-06-82
BOILER ROUTINE PLVR     SO2 ROUTINE=                   PM ROUTINE=                  FLOW FLAG=    3

BOILER SPECIFICATIONS
   Q=      400.0 FLW= 145912    CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=      9600.  S=      0.60 A=      5.40
PM EMISSIONS
   UNC=             CTR=           EFF=          CRF=
SO2 EMISSIONS
   UNC=             CTR=           EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=     0.15 LIME= 35.00 ALS=    8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     31
------------------------------------------------------------------------------------------
ITEM          BOILER            NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
------------------------------------------------------------------------------------------



EQUP         7560504.              0.              0.              0.         7560504.
INST         4021223.              0.              0.              0.         4021223.
TD          11581727.              0.              0.              0.        11581727.
IND          3594800.              0.              0.              0.         3594800.
TDI         15176527.              0.              0.              0.        15176527.
CONT         3035305.              0.              0.              0.         3035305.
TK          18211824.              0.              0.              0.        18211824.
LAND            4000.              0.              0.              0.            4000.
WC            774010.              0.              0.              0.          774010.
TOTL        18989824.              0.              0.              0.        18989824.

DL            406848.              0.              0.              0.          406848.
SPRV          110674.              0.              0.              0.          110674.
MANT          215444.              0.              0.              0.          215444.
SP            262766.              0.              0.              0.          262766.
ELEC              0.               0.              0.              0.              0.
UC            396920.              0.              0.              0.          396920.
WTR               0.               0.              0.              0.              0.
SW             15136.              0.              0.              0.           15136.
SLDG              0.               0.              0.              0.              0.
LW                0.               0.              0.              0.              0.
SC                0.               0.              0.              0.              0.
LMS               0.               0.              0.              0.              0.
LIME              0.               0.              0.              0.              0.
NH3               0.               0.              0.              0.              0.
LYE               0.               0.              0.              0.              0.
FUEL         5066783.              0.              0.              0.         5066783.
TDOM         6474571.              0.              0.              0.         6474571.
OH            380945.              0.              0.              0.          380945.
TOTL         6855515.              0.              0.              0.         6855515.

CR           2394854.              0.              0.              0.         2394854.
WCC            77401.              0.              0.              0.           77401.
MISC          728473.              0.              0.              0.          728473.
TCC          3200727.              0.              0.              0.         3200727.
TOTL        10056242.              0.              0.              0.        10056242.
```

LSC-400-Unc, SM

```
MODEL BOILER  32                                          4-06-82
BOILER ROUTINE PLVR     SO2 ROUTINE=                              PM ROUTINE= SM            FLOW FLAG=     3

BOILER SPECIFICATIONS



   Q=      400.0 FLW=145912   CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=     9600. S=      0.60 A=      5.40
PM EMISSIONS
   UNC=    2.390 CTR=  1.000 EFF=  58.20 CRF= 0.1315
SO2 EMISSIONS
   UNC=          CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=    0.15 LIME= 35.00 ALS=    8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.     32
----------------------------------------------------------------------------------------
ITEM          BOILER              NOX CONTROL     SO2 CONTROL    PM CONTROL       TOTAL
----------------------------------------------------------------------------------------

EQUP         7560504.                 0.               0.          247678.        7808181.
INST         4021223.                 0.               0.              0.         4021223.
TD          11581727.                 0.               0.          247678.       11829404.
IND          3594800.                 0.               0.           82559.        3677359.
TDI         15176527.                 0.               0.          330237.       15506764.
CONT         3035305.                 0.               0.           66047.        3101352.
TK          18211824.                 0.               0.          396284.       18608096.
LAND            4000.                 0.               0.              0.            4000.
WC            774010.                 0.               0.           20784.         794794.
TOTL        18989824.                 0.               0.          417068.       19406880.

DL            406848.                 0.               0.           19706.         426555.
SPRV          110674.                 0.               0.            2956.         113630.
MANT          215444.                 0.               0.           11925.         227369.
SP            262766.                 0.               0.            1651.         264417.
ELEC              0.                  0.               0.           24980.          24980.
UC            396920.                 0.               0.              0.          396920.
WTR               0.                  0.               0.              0.              0.
SW             15136.                 0.               0.           21918.          37054.
SLDG              0.                  0.               0.              0.              0.
LW                0.                  0.               0.              0.              0.
SC                0.                  0.               0.              0.              0.
LMS               0.                  0.               0.              0.              0.
LIME              0.                  0.               0.              0.              0.
NH3               0.                  0.               0.              0.              0.
LYE               0.                  0.               0.              0.              0.
FUEL         5066783.                 0.               0.              0.         5066783.
TDOM         6474571.                 0.               0.           83136.        6557707.
OH            380945.                 0.               0.           15334.         396279.
TOTL         6855515.                 0.               0.           98470.        6953984.



CR           2394854.                 0.               0.           52111.        2446965.
WCC            77401.                 0.               0.            2078.          79479.
MISC          728473.                 0.               0.           15851.         744324.
TCC          3200727.                 0.               0.           70041.        3270768.
TOTL        10056242.                 0.               0.          168511.       10224753.
```

LSC-400-Unc, SSS

```
MODEL BOILER  33                                  4-06-82
BOILER ROUTINE PLVR    SO2 ROUTINE=                   PM ROUTINE= SSS         FLOW FLAG=    3

BOILER SPECIFICATIONS
   Q=     400.0 FLW=145912   CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=     9600. S=     0.60 A=      5.40
PM EMISSIONS
   UNC=   2.390 CTR=  0.200 EFF=  91.60 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    33
-------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
-------------------------------------------------------------------------------

EQUP         7560504.            0.             0.          477284.      8037787.
INST         4021223.            0.             0.               0.      4021223.
TD          11581727.            0.             0.          477284.     12059010.
IND          3594800.            0.             0.          159095.      3753894.
TDI         15176527.            0.             0.          636379.     15812905.
CONT         3035305.            0.             0.          127276.      3162580.
TK          18211824.            0.             0.          763654.     18975472.
LAND            4000.            0.             0.               0.         4000.
WC            774010.            0.             0.           33049.       807059.
TOTL        18989824.            0.             0.          796703.     19786512.

DL            406848.            0.             0.           27589.       434437.
SPRV          110674.            0.             0.            4138.       114812.
MANT          215444.            0.             0.           24455.       239899.
SP            262766.            0.             0.            3182.       265948.
ELEC              0.             0.             0.           38301.        38301.




UC            396920.            0.             0.               0.       396920.
WTR               0.             0.             0.               0.            0.
SW             15136.            0.             0.           34532.        49668.
SLDG              0.             0.             0.               0.            0.
LW                0.             0.             0.               0.            0.
SC                0.             0.             0.               0.            0.
LMS               0.             0.             0.               0.            0.
LIME              0.             0.             0.               0.            0.
NH3               0.             0.             0.               0.            0.
LYE               0.             0.             0.               0.            0.
FUEL         5066783.            0.             0.               0.      5066783.
TDOM         6474571.            0.             0.          132197.      6606767.
OH            380945.            0.             0.           23711.       404656.
TOTL         6855515.            0.             0.          155908.      7011422.

CR           2394854.            0.             0.          100421.      2495274.
WCC            77401.            0.             0.            3305.        80706.
MISC          728473.            0.             0.           30546.       759019.
TCC          3200727.            0.             0.          134272.      3334998.
TOTL        10056242.            0.             0.          290179.     10346421.
```

LSC-400-Unc, VS

```
MODEL BOILER  34                                  4-06-82
BOILER ROUTINE PLVR    SO2 ROUTINE=                   PM ROUTINE= VS          FLOW FLAG=    3
BOILER SPECIFICATIONS
   Q=     400.0 FLW=145912    CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=     9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   2.390 CTR=  0.100 EFF=  95.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    34
----------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL      TOTAL
----------------------------------------------------------------------------

EQUP          7560504.           0.              0.             360859.       7921362.
INST          4021223.           0.              0.             254535.       4275758.




TD           11581727.           0.              0.             615394.      12197121.
IND           3594800.           0.              0.             202523.       3797323.
TDI          15176527.           0.              0.             817917.      15994444.
CONT          3035305.           0.              0.             163583.       3198888.
TK           18211824.           0.              0.             981501.      19193312.
LAND             4000.           0.              0.                  0.          4000.
WC             774010.           0.              0.              51440.        825450.
TOTL         18989824.           0.              0.            1032941.      20022752.

DL             406848.           0.              0.              39413.        446261.
SPRV           110674.           0.              0.                  0.        110674.
MANT           215444.           0.              0.              46285.        261729.
SP             262766.           0.              0.                  0.        262766.
ELEC                0.           0.              0.                  0.             0.
UC             396920.           0.              0.              83953.        480872.
WTR                 0.           0.              0.                  0.             0.
SW              15136.           0.              0.              36109.         51245.
SLDG                0.           0.              0.                  0.             0.
LW                  0.           0.              0.                  0.             0.
SC                  0.           0.              0.                  0.             0.
LMS                 0.           0.              0.                  0.             0.
LIME                0.           0.              0.                  0.             0.
NH3                 0.           0.              0.                  0.             0.
LYE                 0.           0.              0.                  0.             0.
FUEL          5066783.           0.              0.                  0.       5066783.
TDOM          6474571.           0.              0.             205759.       6680329.
OH             380945.           0.              0.              34105.        415050.
TOTL          6855515.           0.              0.             239864.       7095378.

CR            2394854.           0.              0.             129067.       2523921.
WCC             77401.           0.              0.               5144.         82545.
MISC           728473.           0.              0.              39260.        767733.
TCC           3200727.           0.              0.             173471.       3374198.
TOTL         10056242.           0.              0.             413335.      10469577.
```

LSC-400-Unc, FF

```
MODEL BOILER  35                                      4-06-82
BOILER ROUTINE PLVR    SO2 ROUTINE=                       PM ROUTINE= FF           FLOW FLAG=    3

BOILER SPECIFICATIONS
   Q=     400.0 FLW=145912    CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=     9600. S=     0.60 A=     5.40



PM EMISSIONS
   UNC=   2.390 CTR=  0.050 EFF=  97.90 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    35
--------------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
--------------------------------------------------------------------------------------

EQUP         7560504.            0.              0.           810402.        8370905.
INST         4021223.            0.              0.           497045.        4518268.
TD          11581727.            0.              0.          1307446.       12889173.
IND          3594800.            0.              0.           433166.        4027965.
TDI         15176527.            0.              0.          1740611.       16917136.
CONT         3035305.            0.              0.           348122.        3383427.
TK          18211824.            0.              0.          2088733.       20300544.
LAND            4000.            0.              0.                0.           4000.
WC            774010.            0.              0.            50205.         824215.
TOTL        18989824.            0.              0.          2138938.       21128752.

DL            406848.            0.              0.            39413.         446261.
SPRV          110674.            0.              0.                0.         110674.
MANT          215444.            0.              0.            23850.         239294.
SP            262766.            0.              0.            39051.         301817.
ELEC               0.            0.              0.                0.              0.
UC            396920.            0.              0.            61609.         458529.
WTR                0.            0.              0.                0.              0.
SW             15136.            0.              0.            36897.          52033.
SLDG               0.            0.              0.                0.              0.
LW                 0.            0.              0.                0.              0.
SC                 0.            0.              0.                0.              0.
LMS                0.            0.              0.                0.              0.
LIME               0.            0.              0.                0.              0.
NH3                0.            0.              0.                0.              0.
LYE                0.            0.              0.                0.              0.
FUEL         5066783.            0.              0.                0.        5066783.
TDOM         6474571.            0.              0.           200820.        6675391.
OH            380945.            0.              0.            38425.         419370.
TOTL         6855515.            0.              0.           239245.        7094760.

CR           2394854.            0.              0.           274668.        2669522.
WCC            77401.            0.              0.             5021.          82422.



MISC          728473.            0.              0.            83549.         812022.
TCC          3200727.            0.              0.           363238.        3563965.
TOTL        10056242.            0.              0.           602483.       10658725.
```

LSC-400-DS(50), DS/PM

```
MODEL BOILER  36                              4-06-82
BOILER ROUTINE PLVR    SO2 ROUTINE= DS            PM ROUTINE=               FLOW FLAG=    3

S STAR (METRIC) =       0.134
S DSTAR (METRIC) =      56.693
BOILER SPECIFICATIONS
   Q=      400.0 FLW=145912   CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=      0.60 A=      5.40
PM EMISSIONS
   UNC=    2.390 CTR=  0.100 EFF=  95.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=    1.190 C,R=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    36
-------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
-------------------------------------------------------------------------------

EQUP          7560504.             0.             0.           0.     7560504.
INST          4021223.             0.             0.           0.     4021223.
TD           11581727.             0.       2027351.           0.    13609078.
IND           3594800.             0.             0.           0.     3594800.
TDI          15176527.             0.             0.           0.    15176527.
CONT          3035305.             0.             0.           0.     3035305.
TK           18211824.             0.       3243762.           0.    21455584.
LAND             4000.             0.             0.           0.        4000.
WC             774010.             0.         89015.           0.      863025.
TOTL         18989824.             0.       3332776.           0.    22322592.

DL             406848.             0.        105000.           0.      511848.
SPRV           110674.             0.         21000.           0.      131674.
MANT           215444.             0.        118101.           0.      333545.
SP             262766.             0.             0.           0.      262766.
ELEC                0.             0.         26718.           0.       26718.




UC             396920.             0.             0.           0.      396920.
WTR                 0.             0.          2060.           0.        2060.
SW              15136.             0.         59582.           0.       74718.
SLDG                0.             0.             0.           0.          0.
LW                  0.             0.             0.           0.          0.
SC                  0.             0.             0.           0.          0.
LMS                 0.             0.             0.           0.          0.
LIME                0.             0.         23598.           0.       23598.
NH3                 0.             0.             0.           0.          0.
LYE                 0.             0.             0.           0.          0.
FUEL          5066783.             0.             0.           0.     5066783.
TDOM          6474571.             0.        356059.           0.     6830629.
OH             380945.             0.         94966.           0.      475911.
TOTL          6855515.             0.        451025.           0.     7306539.

CR            2394854.             0.        426555.           0.     2821408.
WCC             77401.             0.          8901.           0.       86302.
MISC           728473.             0.        129750.           0.      858223.
TCC           3200727.             0.        565207.           0.     3765933.
TOTL         10056242.             0.       1016231.           0.    11072473.
```

LSC-400-DA(50), DA/PM

```
MODEL BOILER  37                               4-06-82
BOILER ROUTINE PLVR    SO2 ROUTINE= DAC           PM ROUTINE=                 FLOW FLAG=    3

S STAR (METRIC)=      0.134
S DSTAR (METRIC)=    56.693
P DSTAR (METRIC)=   484.482
BOILER SPECIFICATIONS
   Q=      400.0 FLW= 145912   CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=     0.60 A=      5.40
PM EMISSIONS
   UNC=    2.390 CTR=  0.100 EFF=  95.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=    1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    37
----------------------------------------------------------------------------------
ITEM        BOILER          NOX CONTROL     SO2 CONTROL    PM CONTROL      TOTAL



----------------------------------------------------------------------------------

EQUP        7560504.             0.              0.           0.        7560504.
INST        4021223.             0.              0.           0.        4021223.
TD         11581727.             0.        1271267.           0.       12852994.
IND         3594800.             0.              0.           0.        3594800.
TDI        15176527.             0.              0.           0.       15176527.
CONT        3035305.             0.              0.           0.        3035305.
TK         18211824.             0.        2011474.           0.       20223296.
LAND           4000.             0.              0.           0.           4000.
WC           774010.             C.          98391.           0.         872401.
TOTL       18989824.             0.        2109865.           0.       21099680.

DL           406848.             0.         105000.           0.         511848.
SPRV         110674.             0.          21000.           0.         131674.
MANT         215444.             0.         101701.           0.         317146.
SP           262766.             0.              0.           0.         262766.
ELEC              0.             0.          49942.           0.          49942.
UC           396920.             0.              0.           0.         396920.
WTR               0.             0.           2184.           0.           2184.
SW            15136.             0.              0.           0.          15136.
SLDG              0.             0.          79826.           0.          79826.
LW                0.             0.              0.           0.              0.
SC                0.             0.          15592.           0.          15592.
LMS               0.             0.              0.           0.              0.
LIME              0.             0.          18320.           0.          18320.
NH3               0.             0.              0.           0.              0.
LYE               0.             0.              0.           0.              0.
FUEL        5066783.             0.              0.           0.        5066783.
TDOM        6474571.             0.         393565.           0.        6868136.
OH           380945.             0.          90702.           0.         471647.
TOTL        6855515.             0.         484267.           0.        7339782.

CR          2394854.             0.         264509.           0.        2659362.
WCC           77401.             0.           9839.           0.          87240.
MISC         728473.             0.          80459.           0.         808932.
TCC         3200727.             0.         354807.           0.        3555533.
TOTL       10056242.             0.         839074.           0.       10895316.
```

LSC-400-DA(50), FF

```
MODEL BOILER  38                                4-06-82
BOILER ROUTINE PLVR    SO2 ROUTINE= DA              PM ROUTINE= FF             FLOW FLAG=    3




S STAR (METRIC)=     0.134
S DSTAR (METRIC)=    56.693
BOILER SPECIFICATIONS
   Q=      400.0 FLW= 145912   CF=   0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=     0.60 A=     5.40
PM EMISSIONS
   UNC=   2.390 CTR=  0.050 EFF=  97.90 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.595 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    38
--------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP         7560504.              0.             0.         810402.      8370905.
INST         4021223.              0.             0.         497045.      4518268.
TD          11581727.              0.        998046.        1307446.     13887218.
IND          3594800.              0.             0.         433166.      4027965.
TDI         15176527.              0.             0.        1740611.     16917136.
CONT         3035305.              0.             0.         348122.      3383427.
TK          18211824.              0.       1607106.        2088733.     21907648.
LAND            4000.              0.             0.              0.         4000.
WC            774010.              0.         75933.          50205.       900148.
TOTL        18989824.              0.       1683038.        2138938.     22811776.

DL            406848.              0.        105000.          39413.       551261.
SPRV          110674.              0.         21000.              0.       131674.
MANT          215444.              0.         79844.          23850.       319138.
SP            262766.              0.             0.          39051.       301817.
ELEC              0.               0.         24031.              0.        24031.
UC            376920.              0.             0.          61609.       458529.
WTR               0.               0.          2184.              0.         2184.
SW             15136.              0.             0.          36897.        52033.
SLDG              0.               0.         37760.              0.        37760.
LW                0.               0.             0.              0.            0.
SC                0.               0.         15592.              0.        15592.
LMS               0.               0.             0.              0.            0.
LIME              0.               0.         18320.              0.        18320.
NH3               0.               0.             0.              0.            0.
LYE               0.               0.             0.              0.            0.




FUEL         5066783.              0.             0.              0.      5066783.
TDOM         6474571.              0.        303731.         200820.      6979121.
OH            380945.              0.         85019.          38425.       504390.
TOTL         6855515.              0.        388750.         239245.      7483509.

CR           2394854.              0.        211334.         274668.      2880856.
WCC            77401.              0.          7593.           5021.        90015.
MISC          728473.              0.         64284.          83549.       876306.
TCC          3200727.              0.        283212.         363238.      3847176.
TOTL        10056242.              0.        671962.         602483.     11330686.
```

LSC-400-DA(90), DA/PM

```
MODEL BOILER  39
BOILER ROUTINE PLVR     SO2 ROUTINE= DAC        04-07-82
                                                     PM ROUTINE=                  FLOW FLAG=    3

S STAR (METRIC)=      0.242
S DSTAR (METRIC)=   102.047
P DSTAR (METRIC)=   484.482
BOILER SPECIFICATIONS
   Q=     400.0 FLW=145912    CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     2.41 H=     9600. S=      0.60 A=      5.40
PM EMISSIONS
   UNC=   2.390 CTR=  0.100 EFF=  95.80 CRF= 0.1315
SO2 EMISSIONS
   UNC=   1.190 CTR=  0.119 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.     39
-------------------------------------------------------------------------------------
ITEM          BOILER            NOX CONTROL    SO2 CONTROL    PM CONTROL       TOTAL
-------------------------------------------------------------------------------------

EQUP         7560504.              0.              0.             0.         7560504.
INST         4021223.              0.              0.             0.         4021223.
TD          11581727.              0.        1338179.             0.        12919906.
IND          3594800.              0.              0.             0.         3594800.
TDI         15176527.              0.              0.             0.        15176527.
CONT         3035305.              0.              0.             0.         3035305.
TK          18211824.              0.        2110504.             0.        20322320.
LAND            4000.              0.              0.             0.            4000.
WC            774010.              0.         111411.             0.          885421.
TOTL        18989824.              0.        2221915.             0.        21211728.

DL            406848.              0.         105000.             0.          511848.
SPRV          110674.              0.          21000.             0.          131674.
MANT          215444.              0.         107054.             0.          322499.
SP            262766.              0.              0.             0.          262766.
ELEC              0.               0.          50682.             0.           50682.



UC            396920.              0.              0.             0.          396920.
WTR               0.               0.           2386.             0.            2386.
SW             15136.              0.              0.             0.           15136.
SLDG              0.               0.         110266.             0.          110266.
LW                0.               0.              0.             0.              0.
SC                0.               0.          16144.             0.           16144.
LMS               0.               0.              0.             0.              0.
LIME              0.               0.          33113.             0.           33113.
NH3               0.               0.              0.             0.              0.
LYE               0.               0.              0.             0.              0.
FUEL         5066783.              0.              0.             0.         5066783.
TDOM         6474571.              0.         445646.             0.         6920216.
OM            380945.              0.          92094.             0.          473039.
TOTL         6855515.              0.         537740.             0.         7393255.

CR           2394854.              0.         277531.             0.         2672385.
WCC            77401.              0.          11141.             0.           88542.
MISC          728473.              0.          84420.             0.          812893.
TCC          3200727.              0.         373093.             0.         3573819.
TOTL        10056242.              0.         910833.             0.        10967074.
```

LSC-400-DA(90), FF

```
MODEL BOILER   40                            04-07-82
BOILER ROUTINE PLVR    SO2 ROUTINE= DA            PM ROUTINE= FF          FLOW FLAG=    3

S STAR (METRIC)=     0.242
S DSTAR (METRIC)=   102.047
BOILER SPECIFICATIONS
   Q=      400.0 FLW= 145912   CF=    0.600 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      2.41 H=     9600. S=      0.60 A=      5.40
PM EMISSIONS
   UNC=    2.390 CTR=  0.050 EFF=  97.90 CRF= 0.1315
SO2 EMISSIONS
   UNC=    1.190 CTR=  0.119 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.     40
-----------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
-----------------------------------------------------------------------------



EQUP       7560504.            0.             0.         810402.       8370905.
INST       4021223.            0.             0.         497045.       4518268.
TD        11581727.            0.       1101460.        1307446.      13990633.
IND        3594800.            0.             0.         433166.       4027965.
TDI       15176527.            0.             0.        1740611.      16917136.
CONT       3035305.            0.             0.         348122.       3383427.
TK        18211824.            0.       1760160.        2088733.      22060704.
LAND          4000.            0.             0.              0.          4000.
WC          774010.            0.         89587.          50205.        913802.
TOTL      18989824.            0.       1849746.        2138938.      22978496.

DL          406848.            0.        105000.          39413.        551261.
SPRV        110674.            0.         21000.              0.        131674.
MANT        215444.            0.         88117.          23850.        327411.
SP          262766.            0.             0.          39051.        301817.
ELEC            0.             0.         24387.              0.         24387.
UC          396920.            0.             0.          61609.        458529.
WTR             0.             0.          2386.              0.          2386.
SW           15136.            0.             0.          36897.         52033.
SLDG            0.             0.         68201.              0.         68201.
LW              0.             0.             0.              0.             0.
SC              0.             0.         16144.              0.         16144.
LMS             0.             0.             0.              0.             0.
LIME            0.             0.         33113.              0.         33113.
NH3             0.             0.             0.              0.             0.
LYE             0.             0.             0.              0.             0.
FUEL       5066783.            0.             0.              0.       5066783.
TDOM       6474571.            0.        358348.         200820.       7033738.
OH          380945.            0.         87170.          38425.        506541.
TOTL       6855515.            0.        445518.         239245.       7540277.

CR         2394854.            0.        231461.         274668.       2900983.
WCC          77401.            0.          8959.           5021.         91380.
MISC        728473.            0.         70406.          83549.        882429.
TCC        3200727.            0.        310826.         363238.       3874791.
TOTL      10056242.            0.        756344.         602483.      11415068.
```

RES-30-Unc, Unc

```
MODEL BOILER   1                                  4-07-82
BOILER ROUTINE RES1    SO2 ROUTINE=                   PM ROUTINE=                  FLOW FLAG=    6
BOILER SPECIFICATIONS
   Q=       30.0 FLW=  9007. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     4.85 H=   18500. S=      3.00 A=      0.10
PM EMISSIONS
   UNC=   0.0    CTR=  0.0    EFF=   0.0  CRF= 0.0
SO2 EMISSIONS
   UNC=   0.0    CTR=  0.0    EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.      1
-------------------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL     SO2 CONTROL     PM CONTROL      TOTAL
-------------------------------------------------------------------------------------------

EQUP          115427.              0.              0.              0.          115427.
INST          185897.              0.              0.              0.          185897.
TD            301324.              0.              0.              0.          301324.
IND            99259.              0.              0.              0.           99259.
TDI           400583.              0.              0.              0.          400583.
CONT           80117.              0.              0.              0.           80117.
TK            480699.              0.              0.              0.          480699.
LAND            2000.              0.              0.              0.            2000.
WC             94718.              0.              0.              0.           94718.
TOTL          577417.              0.              0.              0.          577417.

DL             52584.              0.              0.              0.           52584.
SPRV           34207.              0.              0.              0.           34207.
MANT           15980.              0.              0.              0.           15980.
SP             20522.              0.              0.              0.           20522.
ELEC               0.              0.              0.              0.               0.
UC             21998.              0.              0.              0.           21998.
WTR                0.              0.              0.              0.               0.
SW                 0.              0.              0.              0.               0.
SLDG               0.              0.              0.              0.               0.
LW                 0.              0.              0.              0.               0.



SC                 0.              0.              0.              0.               0.
LMS                0.              0.              0.              0.               0.
LIME               0.              0.              0.              0.               0.
NH3                0.              0.              0.              0.               0.
LYE                0.              0.              0.              0.               0.
FUEL          701019.              0.              0.              0.          701019.
TDOM          846311.              0.              0.              0.          846311.
OH             47832.              0.              0.              0.           47832.
TOTL          894142.              0.              0.              0.          894142.

CR             63212.              0.              0.              0.           63212.
WCC             9472.              0.              0.              0.            9472.
MISC           19228.              0.              0.              0.           19228.
TCC            91912.              0.              0.              0.           91912.
TOTL          986054.              0.              0.              0.          986054.
```

RES-30-Unc, ESP

```
MODEL BOILER   2                                 4-07-82
BOILER ROUTINE RES1    SO2 ROUTINE=                   PM ROUTINE= ESPO          FLOW FLAG=    6

SPECIFIC COLLECTOR AREA(SQ FT/1000 ACFM)=   400.0
TOTAL PLATE AREA (SQ FT)=      3602.7
BOILER SPECIFICATIONS
   Q=       30.0 FLW=  9007. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     4.85 H=   18500. S=     3.00 A=     0.10
PM EMISSIONS
   UNC=   0.230 CTR=  0.050 EFF=  78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=   0.0    CTR=  0.0    EFF=   0.0  CRF= 0.0
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.      2
----------------------------------------------------------------------------------
ITEM          BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
----------------------------------------------------------------------------------

EQUP          115427.              0.             0.         112477.       227904.
INST          185897.              0.             0.         131599.       317496.
TD            301324.              0.             0.         244076.       545400.
IND            99259.              0.             0.          81521.       180780.




TDI           400583.              0.             0.         325597.       726180.
CONT           80117.              0.             0.          65119.       145236.
TK            480699.              0.             0.         390717.       871416.
LAND            2000.              0.             0.              0.         2000.
WC             94718.              0.             0.           5205.        99923.
TOTL          577417.              0.             0.         395922.       973339.

DL             52584.              0.             0.           8331.        60915.
SPRV           34207.              0.             0.              0.        34207.
MANT           15980.              0.             0.           9335.        25315.
SP             20522.              0.             0.           1797.        22320.
ELEC               0.              0.             0.              0.            0.
UC             21998.              0.             0.           1356.        23354.
WTR                0.              0.             0.              0.            0.
SW                 0.              0.             0.              0.            0.
SLDG               0.              0.             0.              0.            0.
LW                 0.              0.             0.              0.            0.
SC                 0.              0.             0.              0.            0.
LMS                0.              0.             0.              0.            0.
LIME               0.              0.             0.              0.            0.
NH3                0.              0.             0.              0.            0.
LYE                0.              0.             0.              0.            0.
FUEL          701019.              0.             0.              0.       701019.
TDOM          846311.              0.             0.          20819.       867130.
OM             47832.              0.             0.           7560.        55391.
TOTL          894142.              0.             0.          28379.       922521.

CR             63212.              0.             0.          51379.       114591.
WCC             9472.              0.             0.            520.         9992.
MISC           19228.              0.             0.          15629.        34857.
TCC            91912.              0.             0.          67528.       159440.
TOTL          986054.              0.             0.          95907.      1081961.
```

RES-30-NATH(50), NATH/PM

```
MODEL BOILER   3                            4-07-82
BOILER ROUTINE RES1    SO2 ROUTINE= NATH         PM ROUTINE=                FLOW FLAG=    6


S STAR (METRIC)=      0.349
S DSTAR (METRIC)=     11.032
BOILER SPECIFICATIONS
   Q=      30.0 FLW=  9007. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS




   FC=     4.85 H=   18500. S=     3.00 A=     0.10
PM EMISSIONS
   UNC=   0.230 CTR=  0.050 EFF=  78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=   3.210 CTR=  1.610 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     3
----------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL      TOTAL
----------------------------------------------------------------------------------

EQUP          115427.            0.             0.             0.        115427.
INST          185897.            0.             0.             0.        185897.
TD            301324.            0.        165350.             0.        466674.
IND            99259.            0.             0.             0.         99259.
TDI           400583.            0.             0.             0.        400583.
CONT           80117.            0.             0.             0.         80117.
TK            480699.            0.        319118.             0.        799817.
LAND            2000.            0.             0.             0.          2000.
UC             94718.            0.         42338.             0.        137056.
TOTL          577417.            0.        361456.             0.        938873.

DL             52584.            0.        105000.             0.        157584.
SPRV           34207.            0.         21000.             0.         55207.
MANT           15980.            0.         13228.             0.         29208.
SP             20522.            0.             0.             0.         20522.
ELEC               0.            0.          1465.             0.          1465.
UC             21998.            0.             0.             0.         21998.
WTR                0.            0.           222.             0.           222.
SW                 0.            0.             0.             0.             0.
SLDG               0.            0.          3990.             0.          3990.
LW                 0.            0.          2173.             0.          2173.
SC                 0.            0.         22274.             0.         22274.
LMS                0.            0.             0.             0.             0.
LIME               0.            0.             0.             0.             0.
NH3                0.            0.             0.             0.             0.
LYE                0.            0.             0.             0.             0.
FUEL          701019.            0.             0.             0.        701019.
TDOM          846311.            0.        169352.             0.       1015663.
OH             47832.            0.         67699.             0.        115531.
TOTL          894142.            0.        237052.             0.       1131194.

CR             63212.            0.         41964.             0.        105176.




WCC             9472.            0.          4234.             0.         13706.
MISC           19228.            0.         12765.             0.         31993.
TCC            91912.            0.         58962.             0.        150874.
TOTL          986054.            0.        296014.             0.       1282068.
```

RES-30-NATH(50), ESP

```
MODEL BOILER   4                                  4-07-82
BOILER ROUTINE RES1    SO2 ROUTINE= NATH              PM ROUTINE= ESPO          FLOW FLAG=    6

S STAR (METRIC)=      0.349
S DSTAR (METRIC)=     11.032

SPECIFIC COLLECTOR AREA(SQ FT/1000 ACFM)=   400.0
TOTAL PLATE AREA (SQ FT)=      3602.7
BOILER SPECIFICATIONS
   Q=       30.0 FLW=  9007. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     4.85 H=   18500. S=     3.00 A=      0.10
PM EMISSIONS
   UNC=' 0.230 CTR=  0.050 EFF=  78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=   3.210 CTR=  1.610 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     4
---------------------------------------------------------------------------------
ITEM         BOILER          NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
---------------------------------------------------------------------------------

EQUP        115427.              0.             0.          112477.      227904.
INST        185897.              0.             0.          131599.      317496.
TD          301324.              0.        165350.          244076.      710750.
IND          99259.              0.             0.           81521.      180780.
TDI         400583.              0.             0.          325597.      726180.
CONT         80117.              0.             0.           65119.      145236.
TK          480699.              0.        319118.          390717.     1190533.
LAND          2000.              0.             0.               0.        2000.
WC           94718.              0.         42338.            5205.      142261.
TOTL        577417.              0.        361456.          395922.     1334794.

DL           52584.              0.        105000.            8331.      165915.



SPRV         34207.              0.         21000.               0.       55207.
MANT         15980.              0.         13228.            9335.       38543.
SP           20522.              0.             0.            1797.       22320.
ELEC             0.              0.          1465.               0.        1465.
UC           21998.              0.             0.            1356.       23354.
WTR              0.              0.           222.               0.         222.
SW               0.              0.             0.               0.           0.
SLDG             0.              0.          3990.               0.        3990.
LW               0.              0.          2173.               0.        2173.
SC               0.              0.         22274.               0.       22274.
LMS              0.              0.             0.               0.           0.
LIME             0.              0.             0.               0.           0.
NH3              0.              0.             0.               0.           0.
LYE              0.              0.             0.               0.           0.
FUEL        701019.              0.             0.               0.      701019.
TDOM        846311.              0.        169352.           20819.     1036482.
OH           47832.              0.         67699.            7560.      123091.
TOTL        894142.              0.        237052.           28379.     1159572.

CR           63212.              0.         41964.           51379.      156555.
WCC           9472.              0.          4234.             520.       14226.
MISC         19228.              0.         12765.           15629.       47621.
TCC          91912.              0.         58962.           67528.      218402.
TOTL        986054.              0.        296014.           95907.     1377975.
```

RES-30-NATH(90), NATH/PM

```
MODEL BOILER   5                                            4-07-82
BOILER ROUTINE RES1     SO2 ROUTINE= NATH           PM ROUTINE=                 FLOW FLAG=    6

S STAR (METRIC)=       0.628
S DSTAR (METRIC)=     19.858
BOILER SPECIFICATIONS
   Q=       30.0 FLW=   9007. CF=    0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     4.85 H=   18500. S=      3.00 A=     0.10
PM EMISSIONS
   UNC=    0.230 CTR=   0.050 EFF=  78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=    3.210 CTR=   0.321 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=    0.15 LIME= 35.00 ALS=    8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80




COST SUMMARY TABLE - RUN NO.     5
--------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL     SO2 CONTROL     PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP          115427.             0.              0.             0.        115427.
INST          185897.             0.              0.             0.        185897.
TD            301324.             0.         181732.             0.        483056.
IND            99259.             0.              0.             0.         99259.
TDI           400583.             0.              0.             0.        400583.
CONT           80117.             0.              0.             0.         80117.
TK            480699.             0.         343363.             0.        824062.
LAND            2000.             0.              0.             0.          2000.
WC             94718.             0.          47649.             0.        142367.
TOTL          577417.             0.         391012.             0.        968429.

DL             52584.             0.         105000.             0.        157584.
SPRV           34207.             0.          21000.             0.         55207.
MANT           15980.             0.          14539.             0.         30519.
SP             20522.             0.              0.             0.         20522.
ELEC               0.             0.           1632.             0.          1632.
UC             21998.             0.              0.             0.         21998.
WTR                0.             0.            316.             0.           316.
SW                 0.             0.              0.             0.             0.
SLDG               0.             0.           7172.             0.          7172.
LW                 0.             0.           3911.             0.          3911.
SC                 0.             0.          37025.             0.         37025.
LMS                0.             0.              0.             0.             0.
LIME               0.             0.              0.             0.             0.
NH3                0.             0.              0.             0.             0.
LYE                0.             0.              0.             0.             0.
FUEL          701019.             0.              0.             0.        701019.
TDOM          846311.             0.         190596.             0.       1036907.
OH             47832.             0.          68040.             0.        115872.
TOTL          894142.             0.         258636.             0.       1152778.

CR             63212.             0.          45152.             0.        108364.
WCC             9472.             0.           4765.             0.         14237.
MISC           19228.             0.          13735.             0.         32962.
TCC            91912.             0.          63652.             0.        155563.
TOTL          986054.             0.         322288.             0.       1308341.
```

RES-30-NATH(90), ESP

```
MODEL BOILER   6                                4-07-82
BOILER ROUTINE RES1    SO2 ROUTINE= NATH              PM ROUTINE= ESPO         FLOW FLAG=    6

S STAR (METRIC)=      0.628
S DSTAR (METRIC)=     19.858

SPECIFIC COLLECTOR AREA(SQ FT/1000 ACFM)=   400.0
TOTAL PLATE AREA (SQ FT)=      3602.7
BOILER SPECIFICATIONS
   Q=       30.0 FLW=  9007. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      4.85 H=   18500. S=     3.00 A=     0.10
PM EMISSIONS
   UNC=   0.230 CTR=  0.050 EFF=  78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=   3.210 CTR=  0.321 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     6
--------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL   SO2 CONTROL   PM CONTROL      TOTAL
--------------------------------------------------------------------------------

EQUP          115427.              0.            0.       112477.        227904.
INST          185897.              0.            0.       131599.        317496.
TD            301324.              0.       181732.       244076.        727132.
IND            99259.              0.            0.        81521.        180780.
TDI           400583.              0.            0.       325597.        726180.
CONT           80117.              0.            0.        65119.        145236.
TK            480699.              0.       343363.       390717.       1214779.
LAND            2000.              0.            0.            0.          2000.
WC             94718.              0.        47649.         5205.        147572.
TOTL          577417.              0.       391012.       395922.       1364350.

DL             52584.              0.       105000.         8331.        165915.
SPRV           34207.              0.        21000.            0.         55207.
MANT           15980.              0.        14539.         9335.         39853.
SF             20522.              0.            0.         1797.         22320.
ELEC              0.               0.         1632.            0.          1632.
UC             21998.              0.            0.         1356.         23354.
WTR               0.               0.          316.            0.           316.
SW                0.               0.            0.            0.             0.
SLDG              0.               0.         7172.            0.          7172.



LW                0.               0.         3911.            0.          3911.
SC                0.               0.        37025.            0.         37025.
LMS               0.               0.            0.            0.             0.
LIME              0.               0.            0.            0.             0.
NH3               0.               0.            0.            0.             0.
LYE               0.               0.            0.            0.             0.
FUEL          701019.              0.            0.            0.        701019.
TDOM          846311.              0.       190596.        20819.       1057725.
OH             47832.              0.        68040.         7560.        123431.
TOTL          894142.              0.       258636.        28379.       1181156.

CR             63212.              0.        45152.        51379.        159743.
WCC             9472.              0.         4765.          520.         14757.
MISC           19228.              0.        13735.        15629.         48591.
TCC            91912.              0.        63652.        67528.        223092.
TOTL          986054.              0.       322288.        95907.       1404248.
```

RES-30-DA(90), DA/PM

```
MODEL BOILER   7                                4-07-82
BOILER ROUTINE RES1    SO2 ROUTINE= DAC          PM ROUTINE=                FLOW FLAG=    6

S STAR (METRIC)=      0.628
S DSTAR (METRIC)=    19.858
P DSTAR (METRIC)=     1.035
BOILER SPECIFICATIONS
   Q=      30.0 FLW=  9007. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     4.85 H=   18500. S=     3.00 A=     0.10
PM EMISSIONS
   UNC=  0.230 CTR=  0.100 EFF=  56.50 CRF= 0.1315
SO2 EMISSIONS
   UNC=  3.210 CTR=  0.321 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     7
--------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP         115427.             0.             0.             0.        115427.
INST         185897.             0.             0.             0.        185897.




TD           301324.             0.        467849.             0.        769172.
IND           99259.             0.             0.             0.         99259.
TDI          400583.             0.             0.             0.        400583.
CONT          80117.             0.             0.             0.         80117.
TK           480699.             0.        786016.             0.       1266714.
LAND           2000.             0.             0.             0.          2000.
WC            94718.             0.         46296.             0.        141014.
TOTL         577417.             0.        832312.             0.       1409728.

DL            52584.             0.        105000.             0.        157584.
SPRV          34207.             0.         21000.             0.         55207.
MANT          15980.             0.         37428.             0.         53408.
SP            20522.             0.             0.             0.         20522.
ELEC              0.             0.          3025.             0.          3025.
UC            21998.             0.             0.             0.         21998.
WTR               0.             0.           204.             0.           204.
SW                0.             0.             0.             0.             0.
SLDG              0.             0.         12034.             0.         12034.
LW                0.             0.             0.             0.             0.
SC                0.             0.           713.             0.           713.
LMS               0.             0.             0.             0.             0.
LIME              0.             0.          5780.             0.          5780.
NH3               0.             0.             0.             0.             0.
LYE               0.             0.             0.             0.             0.
FUEL         701019.             0.             0.             0.        701019.
TDOM         846311.             0.        185184.             0.       1031495.
OH            47832.             0.         73991.             0.        121823.
TOTL         894142.             0.        259175.             0.       1153317.

CR            63212.             0.        103361.             0.        166573.
WCC            9472.             0.          4630.             0.         14101.
MISC          19228.             0.         31441.             0.         50669.
TCC           91912.             0.        139431.             0.        231343.
TOTL         986054.             0.        398607.             0.       1384660.
```

RES-30-DA(90), ESP

```
MODEL BOILER   8                                 4-07-82
BOILER ROUTINE RES1    SO2 ROUTINE= DA                PM ROUTINE= ESPO          FLOW FLAG=    6

S STAR (METRIC)=      0.628
S DSTAR (METRIC)=     19.858




SPECIFIC COLLECTOR AREA(SQ FT/1000 ACFM)=   400.0
TOTAL PLATE AREA (SQ FT)=      3602.7
BOILER SPECIFICATIONS
   Q=        30.0 FLW=  9007. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     4.85 H=   18500. S=     3.00 A=     0.10
PM EMISSIONS
   UNC=   0.230 CTR=  0.050 EFF=  78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=   3.210 CTR=  0.321 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.     8
--------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP         115427.             0.             0.       112477.       227904.
INST         185897.             0.             0.       131599.       317496.
TD           301324.             0.        375895.       244076.       921294.
IND           99259.             0.             0.        81521.       180780.
TDI          400583.             0.             0.       325597.       726180.
CONT          80117.             0.             0.        65119.       145236.
TK           480699.             0.        649924.       390717.      1521339.
LAND           2000.             0.             0.            0.         2000.
WC            94718.             0.         44044.         5205.       143967.
TOTL         577417.             0.        693968.       395922.      1667305.

DL            52584.             0.        105000.         8331.       165915.
SPRV          34207.             0.         21000.            0.        55207.
MANT          15980.             0.         30072.         9335.        55386.
SP            20522.             0.             0.         1797.        22320.
ELEC             0.              0.          1456.            0.         1456.
UC            21998.             0.             0.         1356.        23354.
WTR              0.              0.           204.            0.          204.
SW               0.              0.             0.            0.            0.
SLDG             0.              0.         11951.            0.        11951.
LW               0.              0.             0.            0.            0.
SC               0.              0.           713.            0.          713.
LMS              0.              0.             0.            0.            0.
LIME             0.              0.          5780.            0.         5780.
NH3              0.              0.             0.            0.            0.
LYE              0.              0.             0.            0.            0.
FUEL         701019.             0.             0.            0.       701019.




TDOM         846311.             0.        176176.        20819.      1043306.
OH            47832.             0.         72079.         7560.       127470.
TOTL         894142.             0.        248254.        28379.      1170774.

CR            63212.             0.         85465.        51379.       200056.
WCC            9472.             0.          4404.          520.        14397.
MISC          19228.             0.         25997.        15629.        60854.
TCC           91912.             0.        115866.        67528.       275306.
TOTL         986054.             0.        364121.        95907.      1446081.
```

RES-150-Unc, Unc

```
MODEL BOILER   9                                    4-07-82
BOILER ROUTINE RNG1    SO2 ROUTINE=                    PM ROUTINE=                FLOW FLAG=    6

BOILER SPECIFICATIONS
   Q=      150.0 FLW= 45034. CF=    0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      4.85 H=   18500. S=      3.00 A=      0.10
PM EMISSIONS
   UNC=   0.230 CTR=  0.050 EFF=  78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=        .  CTR=          EFF=          CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.     9
-----------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL     SO2 CONTROL     PM CONTROL      TOTAL
-----------------------------------------------------------------------------------

EQUP          773660.             0.              0.             0.        773660.
INST          339734.             0.              0.             0.        339734.
TD           1113393.             0.              0.             0.       1113393.
IND           357298.             0.              0.             0.        357298.
TDI          1470690.             0.              0.             0.       1470690.
CONT          294138.             0.              0.             0.        294138.
TK           1764827.             0.              0.             0.       1764827.
LAND             2000.            0.              0.             0.          2000.
WC            359108.             0.              0.             0.        359108.
TOTL         2125934.             0.              0.             0.       2125934.

DL            105825.             0.              0.             0.        105825.
SPRV           34207.             0.              0.             0.         34207.



MANT           34329.             0.              0.             0.         34329.
SP             48068.             0.              0.             0.         48068.
ELEC               0.             0.              0.             0.             0.
UC             46105.             0.              0.             0.         46105.
WTR                0.             0.              0.             0.             0.
SW                 0.             0.              0.             0.             0.
SLDG               0.             0.              0.             0.             0.
LW                 0.             0.              0.             0.             0.
SC                 0.             0.              0.             0.             0.
LMS                0.             0.              0.             0.             0.
LIME               0.             0.              0.             0.             0.
NH3                0.             0.              0.             0.             0.
LYE                0.             0.              0.             0.             0.
FUEL         3505095.             0.              0.             0.       3505095.
TDOM         3773628.             0.              0.             0.       3773628.
OH             89579.             0.              0.             0.         89579.
TOTL         3863206.             0.              0.             0.       3863206.

CR            232075.             0.              0.             0.        232075.
WCC            35911.             0.              0.             0.         35911.
MISC           70593.             0.              0.             0.         70593.
TCC           338579.             0.              0.             0.        338579.
TOTL         4201784.             0.              0.             0.       4201784.
```

RES-150-Unc, ESP

```
MODEL BOILER  10                                4-07-82
BOILER ROUTINE RNG1    SO2 ROUTINE=                PM ROUTINE= ESPO          FLOW FLAG=    6

SPECIFIC COLLECTOR AREA(SQ FT/1000 ACFM)=   400.0
TOTAL PLATE AREA (SQ FT)=    18013.7
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 45034. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     4.85 H=   18500. S=     3.00 A=     0.10
PM EMISSIONS
   UNC=   0.230 CTR=  0.050 EFF=  78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=         CTR=         EFF=         CRF=
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    10




----------------------------------------------------------------------------------------
ITEM          BOILER         NOX CONTROL     SO2 CONTROL     PM CONTROL       TOTAL
----------------------------------------------------------------------------------------

EQUP          773660.            0.              0.           311087.        1084746.
INST          339734.            0.              0.           342196.         681930.
TD           1113393.            0.              0.           653282.        1766675.
IND           357298.            0.              0.           218196.         575494.
TDI          1470690.            0.              0.           871479.        2342168.
CONT          294138.            0.              0.           174296.         468434.
TK           1764827.            0.              0.          1045774.        2810601.
LAND            2000.            0.              0.                0.           2000.
WC            359108.            0.              0.             9659.         368767.
TOTL         2125934.            0.              0.          1055433.        3181367.

DL            105825.            0.              0.            16281.         122106.
SPRV           34207.            0.              0.                0.          34207.
MANT           34329.            0.              0.            10766.          45094.
SP             48068.            0.              0.             4811.          52878.
ELEC               0.            0.              0.                0.              0.
UC             46105.            0.              0.             6780.          52885.
WTR                0.            0.              0.                0.              0.
SW                 0.            0.              0.                0.              0.
SLDG               0.            0.              0.                0.              0.
LW                 0.            0.              0.                0.              0.
SC                 0.            0.              0.                0.              0.
LMS                0.            0.              0.                0.              0.
LIME               0.            0.              0.                0.              0.
NH3                0.            0.              0.                0.              0.
LYE                0.            0.              0.                0.              0.
FUEL         3505095.            0.              0.                0.        3505095.
TDOM         3773628.            0.              0.            38637.        3812265.
OH             89579.            0.              0.            13167.         102746.
TOTL         3863206.            0.              0.            51805.        3915010.

CR            232075.            0.              0.           137519.         369594.
WCC            35911.            0.              0.              966.          36877.
MISC           70593.            0.              0.            41831.         112424.
TCC           338579.            0.              0.           180316.         518895.
TOTL         4201784.            0.              0.           232121.        4433904.
```

RES-150-DA(50), DA/PM

```
MODEL BOILER  11                           4-07-82



BOILER ROUTINE RNG1    SO2 ROUTINE= DAC         PM ROUTINE=              FLOW FLAG=    6

S STAR (METRIC)=     0.349
S DSTAR (METRIC)=    55.160
P DSTAR (METRIC)=     5.175
BOILER SPECIFICATIONS
   Q=      150.0 FLW= 45034. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      4.85 H=   18500. S=     3.00 A=      0.10
PM EMISSIONS
   UNC=   0.230 CTR=  0.100 EFF=  56.50 CRF= 0.1315
SO2 EMISSIONS
   UNC=   3.210 CTR=  1.610 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    11
--------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP          773660.            0.             0.             0.        773660.
INST          339734.            0.             0.             0.        339734.
TD           1113393.            0.        797059.             0.       1910451.
IND           357298.            0.             0.             0.        357298.
TDI          1470690.            0.             0.             0.       1470690.
CCNT          294138.            0.             0.             0.        294138.
TK           1764827.            0.       1273246.             0.       3038073.
LAND            2000.            0.             0.             0.          2000.
WC            359108.            0.         64991.             0.        424099.
TOTL         2125934.            0.       1338236.             0.       3464170.

DL            105825.            0.        105000.             0.        210825.
SPRV           34207.            0.         21000.             0.         55207.
MANT           34329.            0.         63765.             0.         98093.
SP             48068.            0.             0.             0.         48068.
ELEC               0.            0.         14581.             0.         14581.
UC             46105.            0.             0.             0.         46105.
WTR                0.            0.           747.             0.           747.
SW                 0.            0.             0.             0.             0.
SLDG               0.            0.         34083.             0.         34083.
LW                 0.            0.             0.             0.             0.
SC                 0.            0.          4454.             0.          4454.
LMS                0.            0.             0.             0.             0.




LIME               0.            0.         16335.             0.         16335.
NH3                0.            0.             0.             0.             0.
LYE                0.            0.             0.             0.             0.
FUEL         3505095.            0.             0.             0.       3505095.
TDOM         3773628.            0.        259964.             0.       4033591.
OH             89579.            0.         80839.             0.        170417.
TOTL         3863206.            0.        340302.             0.       4204008.

CR            232075.            0.        167432.             0.        399507.
WCC            35911.            0.          6499.             0.         42410.
MISC           70593.            0.         50930.             0.        121523.
TCC           338579.            0.        224861.             0.        563439.
TOTL         4201784.            0.        565663.             0.       4767447.
```

RES-150-DA(50), ESP

```
MODEL BOILER  12                           4-07-82
BOILER ROUTINE RNG1    SO2 ROUTINE= DA         PM ROUTINE= ESPO         FLOW FLAG=    6

S STAR (METRIC)=     0.349
S DSTAR (METRIC)=    55.160

SPECIFIC COLLECTOR AREA(SQ FT/1000 ACFM)=   400.0
TOTAL PLATE AREA (SQ FT)=    18013.7
BOILER SPECIFICATIONS
   Q=     150.0 FLW= 45034. CF=   0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=     4.85 H=   18500. S=     3.00 A=     0.10
PM EMISSIONS
   UNC=   0.230 CTR=  0.050 EFF=  78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=   3.210 CTR=  1.610 EFF=  50.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    12
--------------------------------------------------------------------------------
ITEM         BOILER         NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP         773660.             0.             0.        311087.       1084746.
INST         339734.             0.             0.        342196.        681930.
TD          1113393.             0.        688805.        653282.       2455480.




IND          357298.             0.             0.        218196.        575494.
TDI         1470690.             0.             0.        871479.       2342168.
CONT         294138.             0.             0.        174296.        468434.
TK          1764827.             0.       1113031.       1045774.       3923632.
LAND           2000.             0.             0.             0.          2000.
WC           359108.             0.         60832.          9659.        429598.
TOTL        2125934.             0.       1173862.       1055433.       4355229.

DL           105825.             0.        105000.         16281.        227106.
SPRV          34207.             0.         21000.             0.         55207.
MANT          34329.             0.         55104.         10766.        100199.
SP            48068.             0.             0.          4811.         52878.
ELEC              0.             0.          7016.             0.          7016.
UC            46105.             0.             0.          6780.         52885.
WTR               0.             0.           747.             0.           747.
SW                0.             0.             0.             0.             0.
SLDG              0.             0.         33671.             0.         33671.
LW                0.             0.             0.             0.             0.
SC                0.             0.          4454.             0.          4454.
LMS               0.             0.             0.             0.             0.
LIME              0.             0.         16335.             0.         16335.
NH3               0.             0.             0.             0.             0.
LYE               0.             0.             0.             0.             0.
•FUEL       3505095.             0.             0.             0.       3505095.
TDOM        3773628.             0.        243326.         38637.       4055591.
OH            89579.             0.         78587.         13167.        181333.
TOTL        3863206.             0.        321914.         51805.       4236923.

CR           232075.             0.        146364.        137519.        515958.
WCC           35911.             0.          6083.           966.         42960.
MISC          70593.             0.         44521.         41831.        156945.
TCC          338579.             0.        196968.        180316.        715863.
TOTL        4201784.             0.        518881.        232121.       4952785.
```

RES-150-DA(90), DA/PM

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MODEL BOILER  13                                  4-07-82
BOILER ROUTINE RNG1    SO2 ROUTINE= DAC              PM ROUTINE=                FLOW FLAG=    6

S STAR (METRIC)=      0.628
S DSTAR (METRIC)=    99.289
P DSTAR (METRIC)=     5.175
BOILER SPECIFICATIONS



   Q=      150.0 FLW= 45034. CF=    0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC= .    4.85 H=   18500. S=     3.00 A=      0.10
PM EMISSIONS
   UNC=   0.230 CTR=  0.100 EFF=  56.50 CRF= 0.1315
SO2 EMISSIONS
   UNC=   3.210 CTR=  0.321 EFF=  90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0253 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80
COST SUMMARY TABLE - RUN NO.    13
--------------------------------------------------------------------------------
ITEM          BOILER        NOX CONTROL    SO2 CONTROL    PM CONTROL     TOTAL
--------------------------------------------------------------------------------

EQUP         773660.            0.             0.             0.       773660.
INST         339734.            0.             0.             0.       339734.
TD          1113393.            0.        881329.             0.      1994722.
IND          357298.            0.             0.             0.       357298.
TDI         1470690.            0.             0.             0.      1470690.
CONT         294138.            0.             0.             0.       294138.
TK          1764827.            0.       1397966.             0.      3162793.
LAND           2000.            0.             0.             0.         2000.
WC           359108.            0.         77227.             0.       436335.
TOTL        2125934.            0.       1475193.             0.      3601127.

DL           105825.            0.        105000.             0.       210825.
SPRV          34207.            0.         21000.             0.        55207.
MANT          34329.            0.         70506.             0.       104835.
SP            48063.            0.             0.             0.        48068.
ELEC             0.             0.         15126.             0.        15126.
UC            46105.            0.             0.             0.        46105.
WTR              0.             0.           806.             0.          806.
SW               0.             0.             0.             0.            0.
SLDG             0.             0.         61232.             0.        61232.
LW               0.             0.             0.             0.            0.
SC               0.             0.          5710.             0.         5710.
LMS              0.             0.             0.             0.            0.
LIME             0.             0.         29529.             0.        29529.
NH3              0.             0.             0.             0.            0.
LYE              0.             0.             0.             0.            0.
FUEL        3505095.            0.             0.             0.      3505095.
TDOM        3773628.            0.        308910.             0.      4082537.
OH            89579.            0.         82592.             0.       172170.
TOTL        3863206.            0.        391502.             0.      4254707.




CR           232075.            0.        183833.             0.       415907.
WCC           35911.            0.          7723.             0.        43634.
MISC          70593.            0.         55919.             0.       126512.
TCC          338579.            0.        247474.             0.       586052.
TOTL        4201784.            0.        638975.             0.      4840759.
```

RES-150-DA(90), ESP

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MODEL BOILER  14                                 4-07-82
BOILER ROUTINE RNG1    SO2 ROUTINE= DA               PM ROUTINE= ESPO          FLOW FLAG=    6

S STAR (METRIC)=       0.628
S DSTAR (METRIC)=      99.289

SPECIFIC COLLECTOR AREA(SQ FT/1000 ACFM)=    400.0
TOTAL PLATE AREA (SQ FT)=     18013.7
BOILER SPECIFICATIONS
   Q=      150.0 FLW= 45034. CF=    0.550 CRF= 0.1315
FUEL SPECIFICATIONS
   FC=      4.85 H=   18500. S=     3.00 A=      0.10
PM EMISSIONS
   UNC=    0.230 CTR=  0.050 EFF=   78.30 CRF= 0.1315
SO2 EMISSIONS
   UNC=    3.210 CTR=  0.321 EFF=   90.00 CRF= 0.1315
COST RATES
   ELEC= 0.0258 WTR=   0.15 LIME= 35.00 ALS=   8.00 SASH= 90.00 SLDG= 15.00 SWD=  15.00 ALWD=  1.80

COST SUMMARY TABLE - RUN NO.    14
-------------------------------------------------------------------------------------------
ITEM          BOILER            NOX CONTROL      SO2 CONTROL      PM CONTROL       TOTAL
-------------------------------------------------------------------------------------------

EQUP          773660.               0.               0.          311087.        1084746.
INST          339734.               0.               0.          342196.         681930.
TD           1113393.               0.          791121.          653282.        2557796.
IND           357298.               0.               0.          218196.         575494.
TDI          1470690.               0.               0.          871479.        2342168.
CONT          294138.               0.               0.          174296.         468434.
TK           1764827.               0.         1264459.         1045774.        4075060.
LAND            2000.               0.               0.               0.           2000.
WC            359108.               0.           73358.            9659.         442125.
TOTL         2125934.               0.         1337817.         1055433.        4519184.




OL            105825.               0.          105000.           16281.         227106.
SPRV           34207.               0.           21000.               0.          55207.
MANT           34329.               0.           63290.           10766.         108384.
SP             48068.               0.               0.            4811.          52878.
ELEC               0.               0.            7278.               0.           7278.
UC             46105.               0.               0.            6780.          52885.
WTR                0.               0.             806.               0.            806.
SW                 0.               0.               0.               0.              0.
SLDG               0.               0.           60820.               0.          60820.
LW                 0.               0.               0.               0.              0.
SC                 0.               0.            5710.               0.           5710.
LMS                0.               0.               0.               0.              0.
LIME               0.               0.           29529.               0.          29529.
NH3                0.               0.               0.               0.              0.
LYE                0.               0.               0.               0.              0.
FUEL         3505095.               0.               0.               0.        3505095.
TDOM         3773628.               0.          293434.           38637.        4105698.
OH             89579.               0.           80715.           13167.         183461.
TOTL         3863206.               0.          374149.           51805.        4289159.

CR            232075.               0.          166276.          137519.         535870.
WCC            35911.               0.            7336.             966.          44213.
MISC           70593.               0.           50578.           41831.         163002.
TCC           338579.               0.          224190.          180316.         743085.
TOTL         4201784.               0.          598339.          232121.        5032243.
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APPENDIX D

COST ESCALATION METHODS

Two cost escalation methods are presented for converting the costs presented in this report (mid-1978 $) to a later year basis. Both methods account for the general inflation trend in equipment and labor.

It is important to differentiate between nominal and real interest rates when using these methods. The nominal interest rate is the actual cost of capital without adjustment for inflation. This is the contract rate paid to acquire capital to construct a control device. The real interest rate is the nominal rate adjusted for inflation. This interest rate is the rate paid for capital in constant dollars. For example, if the nominal interest rate was 16 percent and the general inflation rate was 10 percent then the real interest rate would be 6 percent.

The two escalation methods differ in where the cost escalation to current dollars occurs in the calculations. In the real interest method, all costing is done in constant 1978 dollars using the real interest rate. Then, the resulting annualized cost is brought up to current dollars using a factor to account for inflation. In the nominal interest method, the individual costs of equipment and labor are each brought up to current dollars using inflation factors first. Then, a nominal interest rate is used to calculate the annualized costs. The result is the current dollar cost in the first year. Each subsequent year uses the same capital cost charge but must have the operation and maintenance costs adjusted to that year. Thus, the second method has the disadvantage of not giving a constant dollar level cost for the life of the project. Instead, it tends to "front end load" the cost since the capital charge component of the annualized costs in constant dollars goes down each year.

To convert costs to a later year basis, the following escalation factors may be used:[1]

Basis	Escalation Factor
mid-1979	1.09
mid-1980	1.19
mid-1981	1.37
mid-1982	1.44

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[1] Economic Indicators. Chemical Engineering. 85(21):7, September 25, 1978; 86(20):7, September 24, 1979; 87(21):7, October 20, 1980; 88(21):7, October 19, 1981; 89(9):7, August ___, 1982; 90( ):7.